Sir George Duncan Gibb. Bar.t

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WITHDRAWN

Lectures

on

Physiology

delivered in the St Lawrence School of Medicine at Montreal

BY

George Duncan Gibb MD.

Vol. 2.

Lectures

on

Physiology

Delivered in the St. Lawrence
School of Medicine, at
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BY

George Paxton Girdwood M.D.

Vol. 2.

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Digestion No. 5 concluded –

Vascular Glands –

G D Gibb M D

22nd August 1851

To illustrate

Spleen —— Wassall pl 62 fig 1
Supra renal capsules do 62
Thymus —— do 61
Thyroid —— do 61

6 pages from last lecture print, add 4 pages or so, but describe the structure and glands more particularly —

Digestion No. 5.

Changes of the Food in the Large Intestines.

The uncertainty respecting the changes that the chyme undergoes in the small intestines I have already mentioned in my last lecture. Their general result is that the acid chyme is made alkaline, albumen again appears, the fatty and oily matters are reduced to a state of much more minute division, so that they make the fluid look almost creamy, various gases, chiefly carburets of hydrogen, are developed, and nearly all the nutritive materials of the food, as well as of the bile and other secretions discharged into the intestinal canal, are made capable of being absorbed by either the bloodvessels or the lacteals.

The result of such absorption is that the mixture of chyme and the various secretions is gradually made more consistent and darker, and, at the lower end of the small intestines, contains little more than the insoluble and indigestible matter, such as starch, woody fibre, horny matter, epithelium-cells and mucus-corpuscles, epiderms of both vegetable and animal tissues, crystals of ammonio-magnesian phosphates and other salts, the colouring and fatty matters of the bile, and other excrementitious substances.

The contents of the small intestine continue to be alkaline until they pass into the caecum, when they are said to become acid. From the abundance and size of the tubular glands in the

caecum it has been inferred that they secrete an acid fluid somewhat similar to the gastric juice, and capable of digesting those parts of the food which have passed the action of the gastric juice.

During the passage of the food, now becoming nearly all excrement, along the large intestines, fluid continues to be absorbed, and the mass gradually assumes the consistence and other characters of the faeces expelled from the intestinal canal by the combined action of the abdominal muscles and the muscular coat of the rectum.

The average quantity of solid faecal matter evacuated by the human adult in 24 hours is about 5 ounces. Estimating the quantity consumed daily from 21 to 35½ ounces, it will follow that from 26 to 30½ ounces of solid nutriment are absorbed into the system daily. The remaining 5 ounces consist almost entirely of insoluble and innutritious matter.

According to the analysis of Berzelius which is adopted by Simon, human faeces of consistence sufficient to form a coherent mass are composed of

Water			75.3
Matters soluble in water.	Bile	0.9	5.7
	Albumen	0.9	
	Peculiar extractive	2.7	
	Salts	1.2	
Insoluble residue of the food			7.0
Insoluble matters which are added in the intestinal canal, — mucus, biliary resin, fat, and a peculiar animal matter			14.0
			102.0

The ashes of the human faeces have been analysed by Enderlin who found that 100 parts yielded -

Chloride of sodium & alkaline sulphate	1.367
Tribasic phosphate of soda	2.633
Phosphate of lime & phosphate of magnesia	81.372
Phosphate of iron	2.091
Sulphate of lime	4.564
Silica	7.973
	100.000

Movements of the Intestines.

Their movement is peristaltic or vermicular effected by the alternate contractions and dilatations of successive portions of the intestinal coats. The contractions, which may commence at any point of the intestine, extend in a wave like manner along the tube. In any given portion the longitudinal muscular fibres contract first, or more than the circular; they draw a portion of intestine upwards, or, as it were backwards, over the substance to be propelled, and then the circular fibres of the same portion contracting in succession from above downwards, or, as it were from behind forwards, press on the substance into the portion next below, in which at once the same succession of actions next ensues. These movements take place slowly, and in health are commonly unperceived by the mind; but they are perceptible when they are accelerated under the influence of any irritant.

The movements of the intestines are sometimes retrograde or anti-peristaltic; and there is no hindrance to the backward movement of the contents

of the small intestines. But complete security is afforded against the passage of the contents of the large into the small intestines by the ileo-caecal valve, an apparatus in which are combined the principles of construction observed in the valves of bloodvessels and in that of the pylorus.

Proceeding from above downwards, the muscular fibres of the large intestine become, on the whole stronger in direct proportion to the greater strength required for the onward-moving of the faeces, which are gradually becoming firmer. The greatest strength is in the rectum, at the termination of which a sphincter muscle is placed outside the longitudinal fibres, and holds the orifice close by a constant slight contraction under the influence of the spinal cord.

This then concludes the process of digestion in its termination in the expulsion of the faeces. In a few words I shall recapitulate the process —

turn over ↓ —

Commencing with Prehension and
terminating in Defaecation —

Vascular glands: or glands without Ducts.

The materials separated from the blood by the ordinary process of secretion by glands are always discharged from the organ in which they are formed, and are either straightway expelled from the body, or if they are again received into the blood, it is only after they have been altered from their original condition, as in the cases of the saliva and bile. There appears, however, to be a modification of the process of secretion, in which certain materials are abstracted from the blood, undergo some change, and are added to the lymph or returned to the blood, without being previously discharged from the secreting organ, or made use of for any secondary purpose. The bodies in which this modified form of secretion takes place are usually described as vascular glands, or glands without ducts, and include

the Spleen, the Thymus and Thyroid glands, and the supra-renal capsules.

The evidence in favour of the view that these organs exercise a function analagous to that of secreting glands has been chiefly obtained from recent investigations into their structure, which have shown that all the glands without ducts contain the

same essential structures as the secreting glands, except the ducts. They are mainly composed of vesicles or sacculi, either simple and closed, as in the thyroid, spleen, and supra renal capsules, or variously branched and with the cavities of the several branches communicating in and by common canals, as in the thymus. These vesicles, like the acini of secreting glands, are formed of a delicate homogeneous membrane, are surrounded with a vascular plexus, and are filled with finely molecular albuminous fluid, suspended in which are either granules of fat, or cytoblasts or nuclei, or nucleated cells, or a mixture of all these.

These general resemblances in structure between the vascular glands and the true secernent glands lead to the supposition that both sets of organs pursue, up to a certain point, a similar course in the discharge of their functions.

It is assumed that certain principles in an inferior state of organisation are effused from the vessels into the sacculi, and gradually develop themselves into nuclei or cytoblasts; which may be further developed into cells; that in the growth of these nuclei and cells the materials derived from the blood are elaborated into a higher condition of organisation; and that when liberated by the dissolution of the cells, they pass into the lymphatics, or are again received into the blood whose aptness for nutrition they contribute to maintain.

The opinion that the vascular glands thus serve for the higher organisation of the blood, is supported by their being all especially active in the discharge of their functions during foetal life and childhood; when, for the development and growth of the body, the most abundant supply of highly organized blood is necessary. The bulk of the thymus gland in proportion to that of the body, appears to bear almost a direct proportion to the activity of the body's development and growth, and when, at the period of puberty, the development of the body may be said to be complete, the gland wastes and finally disappears. The thyroid gland and renal capsules, also, though they probably never cease to discharge some amount of function, yet are proportionally much smaller in childhood than in foetal life and infancy; and with the years advancing to the adult period, they diminish yet more in proportionate size and apparent activity of function. The spleen more nearly retains its proportionate size, and enlarges nearly as the whole body does.

The function of the vascular glands seems not essential to life, at least in the adult. The thymus wastes and disappears; no signs of illness attend some of the diseases which wholly destroy the structure of the thyroid gland; and the spleen has been often removed in animals, and in a few instances in men, without any evident ill consequence. It is possible that in such cases, some compensation for the loss of one of the organs may be afforded by an increased activity of function in those

that remain. The experiment to be complete should include the removal of all these organs, an operation hardly possible without immediate danger to life. Nor indeed, would this be certainly sufficient, since there is some reason to suppose that the duties of the spleen, after its removal, might be performed by lymphatic or lacteal glands, between whose structure and that of the vascular glands, there is much resemblance, and which it is said, have been found peculiarly enlarged when the spleen was removed.

Although the functions of all the vascular glands may be similar in so far as they may all alike serve for the elaboration and maintainance of the blood, yet each of them probably discharges a peculiar office, in relation either to the whole economy, or to that of some other organ. The Spleen, from the readiness with which it admits of being distended, and from the fact that it is generally small while gastric digestion is going on, and enlarges when that act is concluded, is supposed to act as a kind of vascular reservoir, or diverticulum to the portal system, or more particularly to the vessels of the stomach. That it may serve such a purpose is also made probable by the enlargement which it undergoes in certain affections of the heart and liver, attended with obstruction to the passage of blood through the latter organ, and by its diminution when the congestion of the portal system is relieved by discharges from the bowels, or by effusion of blood into the stomach. But it can hardly be supposed that in an organ of so great complexity as the spleen, containing so

many other structures besides bloodvessels, a mechanical influence on the circulation should be more than a very subordinate part of its office in the economy. And the same objection lies against the opinion that the thyroid gland is important as a diverticulum for the cerebral circulation, or the thymus for the pulmonary in childhood. These, also, like the spleen, must have peculiar and higher but as yet, unknown offices. Respecting the special office of the thyroid gland, nothing reasonable can be suggested; nor is there any evidence concerning that of the renal capsules. Respecting the thymus gland, the observations of Mr Simon have shown that in the hybernating animals, in which it exists throughout life, as each successive period of hybernation approaches, the thymus greatly enlarges and becomes laden with fat, which accumulates in it and in fat-glands connected with it, in even larger proportion than it does in the ordinary seats of adipose tissue. Hence it appears to serve for the storing-up of materials which, being re-absorbed in the inactivity of the hybernating period, may maintain the respiration and the temperature of the body in the reduced state to which they fall during that time.

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Kidneys and their Secretion

G. D. Libb M.D.

21 October 1851

To illustrate

drawings page 332. E. Kirkes

Any plates I may have to illustrate the anatomy &c

Kayer on Kidney. if possible

Carpenter Manual p 424. fig 125

Fenwicks Carpenter fig 82. p 607

Hassall - plates 58. 59

Uric tables, analysis of the urine -
see my own lecture

Hassall plate 60. figs 2 & 3.

Kidneys and their Secretion).

Structure of the Kidneys. The Kidneys provided especially for the excretion of the refuse nitrogen, phosphorus & and sulphur, lime and magnesia, have the general structure of glands arranged in a manner distinguishing them from all other excretory organs. In each Kidney numerous secreting tubes (tubuli uriniferi) are collected in bundles, in from 10 to 20 separated conical or pyramidal portions (pyramids or cones of Malpighi) which constitute the tubular portion of the Kidney. The apices of the cones converge, and project into calyces, which are branches of a large cavity called the pelvis of the Kidney, that leads to the ureter, its excretory duct. The trunks of the urine-tubes open at the extremities or papillae of the pyramids, and their branches running in straight and somewhat divergent course towards the surface of the Kidney, as they approach it, become tortuous, and winding in various directions, terminate in, or bear on small pedicles proceeding from their walls, dilated, flask-shaped sacculi named Capsules of Malpighi fig. Those that bear capsules at their sides, probably unite with one another in loops, or terminate in simply closed ends.

The small branches of the renal arteries ramify very abundantly in the parts of the Kidney near the surface, and between the several pyramids; and predominating over the tubules, have obtained for these cortical parts of the Kidney the name of vascular portion. Before dividing into capillaries, they form vascular tufts or little balls, called Malpighian corpuscles or glomerules. In the formation of these, each minute artery divides into 4 or more small tortuous branches, which run on the surface of the corpuscles and give off many branches that fill up the spaces between and within them, and lead to a small vein which usually emerges from the corpuscle at the same part as the artery enters it.

Thus each Malpighian ~~capsule~~ corpuscle appears as if suspended by a small short pedicle formed of its artery and vein. (show fig Has Se) Each lies within a Malpighian capsule, or attached to its exterior, and from the vein of each proceed capillaries, which ramify in close networks over the urine-tubes. Thus therefore, the circulation of the Kidney is peculiar in that the capillaries from which the blood is chiefly derived to form the urine, are like the divisions of a vein rather than of an artery; for the branchings of the arteries in the Malpighian tufts or corpuscles, and the collection of their branches again into the small efferent vessel, give that

vessel the character of a vein, and make the cap=illary circulation over the urine tubes analo=gous to the portal circulation through the liver, an analogy which is the closer, because in fish and Amphibia the kidney receives not only a renal artery, whose branches form the Malpighian bodies, but also a large renal (or renal-portal) vein, bringing, for the secretion of urine, the venous blood of the hinder parts of the body, and giving off the capillaries which ramify upon the urine-tubes.

The urine-tubes are minute canals of about $\frac{1}{700}$ of an inch in diameter, formed of hellucid, simple, or basement-membrane, and lined throughout with nucleated gland-cells, arran=ged like an epithelium, of spheroidal form and darkly dotted or granulated (see Fig Has). Not unfrequently, portions of tubes, especially of those that are convoluted or tortuous, appear nearly filled with such cells, or their separated nuclei, as if the urine were filtered through them in its way to the pelvis. The same kind of epithelium is continued into the Malpighian capsules, and lines their whole internal surface, and, if they contain Malpighian tufts, is reflec=ted over them like a serous membrane.

For further description if necessary, next plate.

Secretion of Urine. The separation of urine from the blood is probably effected like other secretions, by the agency of the gland-cells, and equally in all parts of the urine tubes. The urea and uric acid, and perhaps some of the other constituents existing ready formed in the blood, may need only separation, that is, they may pass from the blood to the urine without further elaboration; but this is not the case with some of the other principles of the urine, such as the acid phosphates and the sulphates, for these salts do not exist in the blood, and must be formed by the chemical agency of the cells.

The large size of the renal arteries and veins permit so rapid a transit of the blood through the kidneys, that the whole of the blood is purified by them. The secretion of urine is rapid in comparison with other secretions, and as each portion is secreted it

propels those already in the tubes onwards into the pelvis. There thro the ureter the urine passes into the bladder, into which its rate and mode of entrance has been watched in cases of ectopia vesicae, i.e. of such fissures in the anterior and lower part of the walls of the abdomen, and of the front wall of the bladder, that its hinder wall with the orifices of the ureters is exposed to view. The best observations on such a case were made by Sir Erichsen. The urine does not enter the bladder at any regular rate, nor is there a synchronism in its movement thro the two ureters. During fasting 2 or 3 drops enter the bladder every minute, each drop as it enters first raising up the little papilla on which, in these cases, the ureter opens, and then passing slowly through its orifice, which at once again closes like a sphincter. In the recumbent posture the urine collects for a little time in the ureters, then flows gently, and if the body is raised, runs from them in a stream till they are empty. Its flow is increased in deep inspiration, or straining, and in active exercise, and in 15 or 20 minutes after a meal.

The same observations, also, shewed how fast some substances pass from the stomach through the circulation, and through the vessels of the kidneys. Ferrocyanate of potash so passed on one occasion in a minute; vegetable substances, such as rhubarb, occupied from 16 to 35 minutes; neutral alkaline salts with vegetable bases, which

were generally decomposed in transitu, made the urine alkaline in from 28 to 47 minutes. But the times of passage varied much; and the transit was always slow when the substances were taken during digestion.

The urine collecting in the urinary bladder is prevented from regurgitation into the ureters by the mode in which they pass thro the walls of the bladder, namely, by their lying for between half and 3/4 of an inch between the muscular and mucous coats, and then turning rather abruptly forwards, and opening through the latter. It collects till the distension of the bladder is felt, either by direct sensation, or, in ordinary cases, by a transferred sensation at and near the orifice of the urethra. Then, the effort of the will being directed primarily to the muscles of the abdomen, and through them (by reason of its tendency to act with them, to the urinary bladder), the latter, though its muscular walls, are really composed of involuntary muscle, contracts, and expels the urine. The muscular fibres behind the ureters, where they lie between the muscular and mucous coat of the bladder, compress these canals as they contract for the expulsion of the urine; and the vesical orifice of the urethra, which appears to be closed only by the elasticity of the surrounding parts, is forced open by the pressure of the urine while the bladder is contracting, and again closes by the same elasticity when the bladder ceases to contract.

The Urine: its general Properties.

Healthy urine, is a clear limpid fluid, of a pale yellow or amber colour, with a peculiar faint aromatic odour, which becomes pungent and ammoniacal when decomposition takes place.

The urine, though usually clear and transparent at first, often, as it cools, becomes opaque and turbid from the deposition of part of its constituents previously held in solution; and this may be consistent with health, though it is only in disease that, in the temperature of 98° or 100°, at which it is voided, the urine is turbid even when first expelled. Although ordinarily of a pale amber colour, yet consistently with health, the urine may be nearly colourless, or of a brownish or deep orange tint; and between these extremes it may present every shade of colour.

When secreted, and, most commonly, when first voided, the urine has a distinctly acid reaction in man and all carnivorous animals, and it thus remains till it is neutralized or made alkaline by the ammonia developed in it by decomposition. In most herbivorous animals, on the contrary, the urine is alkaline & turbid.

The difference depends, not on any peculiarity in the mode of secretion, but on the differences in the food on which the two classes subsist: for when carnivorous animals, such as dogs,

are restricted to a vegetable diet, their urine becomes pale, turbid, and alkaline like that of an herbivorous animal, but resumes its former acidity on the return to an animal diet; while the urine voided by herbivorous animals, E.g. rabbits, fed for some time exclusively upon animal substances, presents the acid reaction and other qualities of the urine of carnivora, its ordinary alkalinity being restored only on the substitution of a vegetable for the animal diet. Human urine is not usually rendered alkaline by vegetable diet, but it becomes so after the free use of alkaline medicines, or of the alkaline salts with carbonic or vegetable acids; for these latter are changed into alkaline carbonates previous to elimination by the kidneys. Except in these cases it is very rarely alkaline, unless ammonia has been developed in it by decomposition commencing before it is evacuated from the bladder.

The average specific gravity of the human urine is stated by Dr Prout to be 1020, by Becquerel as the mean in the two sexes 1017. Probably no other animal fluid presents so many varieties in density within 24 hours as the urine does; for the relative quantity of water and of solid constituents of which it is composed is materially influenced by the condition and occupation of the body during the time at which it is secreted, by the length of time which has

elapsed since the last meal, and by several other accidental circumstances. The existence of these causes of difference in the composition of the urine has led to the secretion being described under the 3 heads of urina sanguinis, urina potûs, and urina cibi.

The first of these names signifies the urine, or that part of it, which is secreted from the blood, at times in which neither food nor drink has been recently taken, and is applied especially to the urine which is evacuated in the morning before breakfast. The urina potûs indicates the urine secreted shortly after the introduction of any considerable quantity of fluid into the body; and the urina cibi the portions secreted during the period immediately succeeding a meal of solid food. The latter kind contains a larger quantity of solid matter than either of the others; the former, being largely diluted with water, possesses a comparatively low specific gravity. Of the three kinds, the morning urine is the best calculated for analysis, since it represents the simple secretion unmixed with the elements of food or drink; if it be not used, the whole of the urine passed during a period of 24 hours should be taken. In accordance with the various circumstances which I have just mentioned, the specific gravity of the urine may, consistently with health, range widely on both sides of the usual average. The average healthy

range may be stated at from 1015 in the winter to 1025 in the summer, and variations of diet and exercise may make as great a difference. In disease the variation may be greater; sometimes descending, in albuminuria, to 1004, and frequently ascending, in diabetes, when the urine is loaded with sugar, to 1050, or even to 1060.

The whole quantity of urine secreted in 24 hours is subject to variation according to the amount of fluid drunk, and the quantity secreted by the skin. It is because the secretion of the skin is more active in summer than in winter, that the quantity of urine is smaller & its specific gravity proportionately higher.

According to Prout, the quantity voided in summer may be estimated at 30 ounces daily; that in winter at 40 ounces: this will give a mean of 35 ounces as the average amount of the urinary secretion by an adult healthy man.

Chemical Composition of the Urine.

The urine consists of water, holding in solution certain animal and saline matters as its ordinary constituents, and occasionally various matters taken in the stomach as food – salts, colouring matters, and the like. The quantities of the usual natural and constant ingredients of the urine are stated somewhat differently by the different

chemists who have analysed it; but many of the differences are not important, and the well known accuracy of the several chemists renders it almost immaterial which of the analyses is adopted.

The analysis by A. Becquerel being adopted by Dr Prout, and by Dr Golding Bird, will be here employed.

The older analysis by Berzelius, adopted by Muller, (which is also before you) includes all the principal solid constituents of the urine, and probably states correctly the proportions that they bear to one another; but as pointed out by Dr Prout, it is probable that Berzelius examined urine of very high Sp. gr. and has in consequence overstated the quantity of solid ingredients; for he sets them down at more than double the amount found to exist by more recent analysts.

Water		933.00
Urea		30.10
Uric or Lithic acid		1.00
Free lactic acid, lactate of ammonia, alcohol, and water extract		17.14
Mucus		0.32
Fixed Salts 15.29	Sulphate of Potash	3.71
	Sulphate of Soda	3.16
	Phosphate of Soda	2.94
	Biphosphate of Ammonia	1.65
	Chloride of Sodium	4.45
	Chloride of Ammonium	1.50
	Phosphate of Lime and Magnesia	1.00
	Silicic acid	0.03
		1000.00

Berzelius

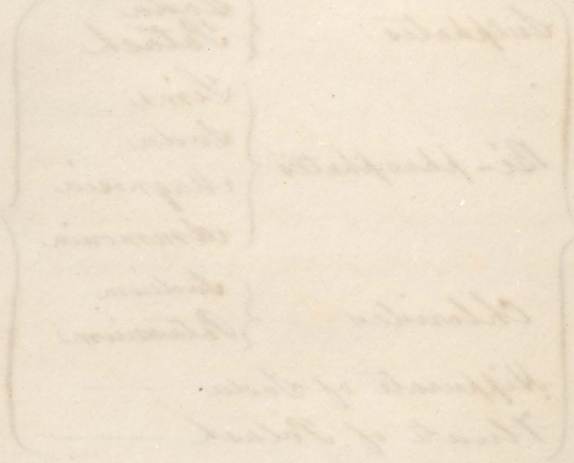
If the mean specific gravity of human urine be taken at 1020, and the average quantity passed in 24 hours be estimated at 35 ounces, it will be found, according to the analysis of M. Becquerel, that 1000

parts of wine contain 33 parts of solid matter dissolved in 967 parts of water. Its more exact composition is as follows: —

Becquerels analysis.

Water		967.
Urea		14.230
Uric acid		.468
Colouring matter, Mucus, and animal extractive matter	inseparable from each other	10.167
Salts: Sulphates: Soda, Potash; Bi-phosphates: Lime, Soda, Magnesia, Ammonia; Chlorides: Sodium, Potassium; Hippurate of Soda; Fluate of Potash		8.135
Silica		traces
		1000.000

From these proportions, however, most of the constituents are, even in health liable to variations. Especially the water is so. Its variations in different seasons, and according to the quantity of drink & exercise I have already mentioned. It is also liable to be influenced by the condition of the nervous system, being sometimes greatly increased in hysteria, and some other nervous affections; and at other times diminished. In some diseases it is enormously increased; and its increase may be either attended with an augmented quantity of solid matter, as in ordinary diabetes, or may be nearly the sole change, as in the affection termed diabetes insipidus. In other diseases



e.g. the various forms of albuminuria, the quantity may be considerably diminished. A febrile condition almost always diminishes the quantity of water; and a like diminution is caused by any affection which draws off a large quantity of fluid from the body through any other channel than that of the kidneys e.g. the bowels and the skin.

I shall now consider some of the constituents of the urine: —

Urea. is the principal solid constituent of the urine, forming nearly one half of the whole quantity of solid matter. It is also the most important ingredient, since it is the chief substance by which the nitrogen of decomposed tissues and superfluous food is secreted from the body. For its removal the secretion of urine seems especially provided, and by its retention in the blood the most pernicious effects are produced.

It exists in a state of solution, but may be procured in the solid state, and then appears in the form of delicate silvery acicular crystals, which under the microscope, appear as 4 sided prisms.

How obtained } evaporating urine to consistence of honey, acting on wh 4 parts of alcohol, then evaporating alcoholic solution, & purifying residue by repeated solution in HO or alcohol & finally crystalising.

It readily combines with an acid, like a weak base. May be procured in form of nitrate - 3ß NO^5 to 3i urine in a watch glass.

The crystals form more rapidly if urine is concentrated — show some in a bottle —

Urea colourless when pure, yellow or brown if impure. Identical in composition with cyanate of Ammonia.

This cyanate of ammonia or artificial urea, as discovered by Wöhler, may be formed by the action mutual of ammonia, cyanic acid and water.

Decomposition of the urea with development of Carb of ammonia ensues spontaneously when the urine is kept for some days after being voided.

In albuminuria quantity is much reduced — Urea is derived principally from the nitrogenized food, it exists also ready formed in the blood.

Uric or Lithic acid. terms. formerly called the latter from its forming constituent of calculi. Is another nitrogenous animal substance. In man quantity 1 in 2000 parts. In birds & serpents quantity very large. Is increased in the urine by the use of animal food, & decreased by food void of N. In febrile diseases & plethora, formed in very large quantities, & in gout deposited in tissues in & around joints in the form of urate of soda, called Chalk stones. In the urine, uric acid is supposed to be in combination with some base, probably ammonia, in form of urate of ammonia, supported by the fact, that on adding an acid to urine, crystals of uric acid are deposited. Uric acid in excrement of birds & serpents is not in the free state but combined with ammonia.

Hippuric acid has long been known to exist in the urine of herbivorous animals in combination with soda. Liebig has lately shown that it also exists naturally in the urine of man, in quantity equal to uric acid; but according to Dr J. Bird its quantity is not more than 1/3 of the uric acid. When benzoic acid is introduced into the system it is excreted by the kidneys as hippuric acid.

The Mucus in the urine consists principally of the epithelial debris of the mucous surface of the urinary passages. In inflammatory affections of these passages, especially of the bladder, mucus in large quantities is poured forth & speedily undergoes decomposition.

Salts The saline substances in urine constitute about one fourth of the solid ingredients. They consist of the various saline matters found in the other fluids and tissues of the body, together with some that are peculiar to the urine.

The sulphates are the most abundant; they exist as the sulphates of soda and potash.

The phosphates are more numerous, though less abundant than the sulphates. The presence of the acid phosphates accounts, in great measure, or, according to Liebig, entirely for the acidity of the urine. The phosphates are taken largely in both vegetable and animal food.

The chlorides occur as chlorides of potassium and sodium. as they exist largely in food, and in most of the animal fluids, their presence is easily understood.

Fluate of potash & silica are only occasionally present.

28

Elementary Structures of the Nervous System.

G. Gibbs MD

17th Decem 1851

To illustrate

Fig 30. Kirkes
" 52. C. Todd
" 59 Todd & 60 of ditto.
67. 63. Carpenter Manual
Pacchionian Corpuscles in Todd, Kirkes & Hassall
33. 34 & 35 of Kirkes
34. 55 & 56 of Todd.

The Nervous System.

The nervous system consists of 2 portions, or constituent systems, the Cerebro-spinal, and the Sympathetic or ganglionic, each of which (though they have many things in common) possesses certain peculiarities in structure, mode of action, and range of influence.

The Cerebro-spinal system includes the brain and spinal cord, with the nerves proceeding from them, and the several ganglia seated upon these nerves, or forming part of the substance of the brain. It was denominated by Bichat the nervous system of animal life; and includes all the nervous organs in and through which are performed the several functions with which the mind is more immediately connected; namely, those relating to sensation and volition, and the mental acts connected with sensible things.

The Sympathetic or ganglionic portion of the nervous system, which Bichat named the nervous system of organic life, consists essentially of a chain of ganglia connected by nervous cords, which extends from the cranium to the pelvis, along each side of the vertebral column, and from which nerves with ganglia proceed to the viscera in the thoracic, abdominal, and pelvic cavities. By its distribution, as well as by its peculiar mode of action, this system is less

immediately

immediately connected with the mind, either as sensiferous or as receiving the impulses of the will, it is more closely connected than the cerebro-spinal system is with the processes of organic life.

But the differences between these 2 systems, are not essential: their actions differ more in degree and object, than in kind or mode: in the lower animals all the nervous functions are performed by one system corresponding with the cerebro-spinal of the Vertebrata; and among the Vertebrata many of the functions which in the warm-blooded animals are controlled by the sympathetic nerves, are in fish under the control of the pneumogastric cerebral nerves.

Elementary Structures of the Nervous System.

The organs of the nervous system, or systems, are composed essentially of 2 kinds of structure, vesicular and fibrous; both of which appear essential to the construction of even the simplest nervous system.

The fibrous-nerve substance, or nervous matter, besides entering into the composition of the nervous centres, forms along the nerves, xxx cords of communication, which connect the various nervous centres, and are distributed in the several parts of the body for the purpose of, conveying nervous force to them, or of transmitting to the nervous

& Todd & Bowman consider this membrane analagous to the sarcolemma of striped muscle, and that it does not possess distinct long: or oblig: fibres as described by some writers.

centres the impressions made by stimuli. By the term nervous centres is meant, the collection of the vesicular structure in masses, mingled with the fibrous structure, as in the brain, Spinal cord, and the several ganglia.

We have 2 kinds of primitive fibre in the nervous system, and these are the

1 } Tubular fibre, or the nerve-tube,
2 } and the Gelatinous-fibre.

The former are infinitely the more numerous; # the latter being found chiefly in the sympathetic system. In most nerves however, the 2 kinds of fibres are mingled.

1 Of the Tubular Fibre. These are minute fibres or tubules full of nervous matter, arranged in parallel or interlacing bundles, which bundles are connected by intervening fibro-cellular tissue, in which their principal blood-vessels ramify. A layer of the same, or of strong fibrous tissue also surrounds the whole nerve, and forms a sheath or neurilemma for it.

These tubules consist of a pellucid simple membrane, within which is contained the proper nerve-substance, consisting of a transparent oil-like, and apparently homogeneous material, which gives to each fibre the appearance of a fine glass-tube filled with a clear transparent fluid. (Fig 30. A of Kirkes). This simplicity,

and characteristic of, the nerves of the cerebro-spinal system.

of composition is, however, only apparent in the fibres of a perfectly fresh nerve; for shortly after death they undergo changes which make it probable that their contents are composed of 2 different materials. The internal, or central part, occupying the axis of the tube, becomes greyish, while the outer, or cortical, portion becomes opaque and dimly granular or grumous, as if from a kind of coagulation. At the same time, the fine outline of the previously transparent cylindrical tube is exchanged for a dark double contour (fig 30. B.), the outer line being formed by the sheath of the fibre, the inner by the margin of curdled or coagulated medullary substance. The granular material shortly collects into little masses, which distend portions of the tubular membrane, while the intermediate spaces collapse, giving the fibres a varicose, or beaded appearance, (fig 30. C & D) instead of their previous cylindrical form.

The differences produced in the contents of the nerve-fibres when exposed to the same conditions, has, with other facts, led to the opinion that the central part of each nerve fibre differs from the circumferential portion: and the former has been named by Rosenthal and Purkinje the axis-cylinder, by Remak the primitive band. The outer portion is usually

called the medullary or white substance of Schwann being that to which the peculiar white aspect of cerebro-spinal nerves is principally due.

The whole contents of the nerve tubules appear to be extremely soft, for when subjected to pressure they readily pass from one part of the tubular sheath to another, and often cause a bulging at the side of the membrane. They also readily escape on pressure from the extremities of the tubule, in the form of a grumous or granular material.

The size of the nerve-fibres varies, and the same fibres do not preserve the same diameter through their whole length, being largest in their course within the trunks and branches of the nerves, in which the majority measure from 2000 th to 3000 th of an inch in diameter. As they approach the brain or spinal cord, and generally also in the tissues in which they are distributed, they gradually become smaller. In the grey or vesicular substance of the brain and spinal cord, they generally do not measure more than from 10.000 to 14.000 of an inch.

2 Of the Gelatinous nerve-fibre. This term was first applied by Henle, to this kind of fibre. These fibres constitute the principal part of the trunk and branches of the sympathetic nerves, and are mingled in various proportions in the cerebro-spinal nerves. They differ from the

Tubular fibre in the following:

They are much smaller and finer, being only about ½ or ⅓ as large in their course within the trunks and branches of the nerves.

In the absence of the double contour.

In their contents being apparently uniform.

And in their having, when in bundles, a yellowish grey hue instead of the whiteness of the cerebro-spinal nerves.

These peculiarities make it probable that they differ from the other nerve-fibres, in not possessing the outer layer of white or medullary substance nerve; and that their contents are composed exclusively of the substance corresponding with the central portion, or axis-cylinder of the larger fibres.

The fibres are flattened, contain numerous cell-nuclei, some round, some oval, some situated in the centre and others adhering to the edge of the fibre; their longest diameter parallel to the long axis of the nerve. These nuclei frequently exhibit nucleoli. (Fig 52. C. Todd)

— It is supposed however that there is not a material difference in the office or mode of action of the Tubular and Gelatinous nerve fibres, as many are found which appear to be intermediate in character between these two kinds, and many large fibres, gradually diminish in size, as they approach both their central and their peripheral ends.

Course of Nerve fibres. Every nerve fibre in its course, proceeds uninterruptedly from its origin at a nervous centre to its destination, whether this be at the periphery of the body, in another nervous centre, or in the same centre whence it issued. In the whole of its course, also, however long, there is no branching, or anastomosis or union with the substance of any other fibres.

Bundles or fasciculi of fibres, run together in the nerves, but merely lie in apposition with each other; they do not unite: even where the fasciculi appear to anastomose there is no union of fibres, but only an interchange of fibres between the anastomosing fasciculi. (Fig 59 of Todd)

Hence the central extremity of each fibre is connected with the peripheral extremity of a single nervous fibre only; and this peripheral extremity is in direct relation with only one point of the brain, spinal cord, or other nervous centre; so that, corresponding to the many millions of primitive fibres which are distributed to peripheral parts of the body, there are the same number of peripheral points of the body represented in the nervous centres.

At certain parts of their course nerves form plexuses in which they anastomose with each other, and interchange fasciculi, as in the case of the brachial and lumbar plexuses. The object of such interchange of fibres is, probably, to give to each nerve passing off from the plexus a wider connection with the spinal cord than it would

have if it proceeded to its destination without such communication with other nerves. Thus, since the brachial plexus is formed by the intermingling of fasciculi from the 4 last cervical, and the first dorsal nerves, it is possible that each trunk coming off from it may contain fibres derived from several parts of the cord intermediate between the roots of the 4th cervical & those of the 1st dorsal. By this means the parts supplied from the brachial plexus are enabled to have wider relations with the nervous centres, and more extensive sympathies.

Of Terminations of nerve-fibres. The terminations of nerve fibres are their modes of distribution and connection in the nervous centres, and in the parts which they supply: the former are called their central, the latter their peripheral terminations.

As they approach their final and minutest distribution in the several tissues, the small bundles of nerve-fibres commonly form delicate plexuses, the terminal plexuses. These, then dividing or breaking up, give off the primitive fibres which appear to be disposed of in various ways, in different tissues. It is exceedingly difficult to determine how they terminate; but examples of each of the four following modes have been observed.

1 In loops.* In this (which can only conventionally be called a mode of termination) each fibre, after

* fig 60 of Todd. fig 67. Cycl. Manual. & fig 63. ditto.

issuing from a branch in a terminal plexus, runs over the elementary structures of the containing tissue then turns back, and joins the same or a neighbouring branch, in which it probably pursues its way back to a nervous centre. This arrangement has been found in the internal ear, in the papillae of the tongue, in the touch pulp: it probably exists also in the tactile papillae of the skin and in a modified form, in striped muscular tissue. (Show figures

But in the latter, Wagner and Volkmann assert that each ultimate fibre breaks up into several branches, which spread out over the muscular fibres, and according to Wagner, penetrate within the sarcolemma of each fibril.

2. In plexuses. In this form, nerve-fibres appear to terminate in certain serous membranes. According to Mr Rainey the arachnoid membrane of the brain and spinal cord is traversed by innumerable delicate nerve-fibres, arranged in minute plexuses; and a similar mode of arrangement appears to be observed by the nerve-fibres in other serous membranes, e.g. the peritoneum.

3. By free ends. It is not improbable that this mode of termination exists in several parts, as in the retina, and possibly in the papillae of the skin; but it has been determined only in the Pacinian Corpuscles. (show various figs of)

Todd. Kirkes. Hassall.

Pacinian Corpuscles. These corpuscles are elongated, little oval bodies, situated on some of the cerebro-spinal and sympathetic nerves, especially the cutaneous nerves of the hands and feet. They are named Pacinian, after their discoverer, Pacini. Each corpuscle is attached by a narrow pedicle to the nerve on which it is situated; it is formed of several concentric layers of fine membrane*, with intervening spaces containing fluid; through its pedicle passes a single nerve fibre, which, after traversing the several concentric layers and their intermediate spaces, enters a central cavity, and gradually losing its dark border, and becoming smaller, terminates at or near the distal end of the cavity, in a knob-like enlargement, or by bifurcating. The enlargement commonly found at the end of the fibre, is said by Pacini to resemble a ganglion corpuscle; but this observation has not been confirmed.

4. Another mode of termination of nerve fibres has been described by Wagner as occurring in the electric organ of the ray. A large nerve fibre suddenly breaks up into from 12 to 15 branches, each of which again divides into 2 secondary branches. Some of these secondary branches anastomose and form a network; while others divide again dichotomously, each of these branches again anastomosing and subdividing,

* from 30 to 60, or more in number, enclosed one within the other

until a very fine network is formed, from which branches pass off, and seem to be lost in the substance of the electric organs.

The central termination of nerve fibres will be considered after the account of the vesicular nerve substance.

The Vesicular nervous substance, or Nervous matter, is composed, as its name implies, of vesicles or corpuscles, which are commonly called nerve-corpuscles, or ganglion corpuscles. These are found only in the nervous centres, i. e. the brain, spinal cord, and the various ganglia; they are mingled with nerve fibres, and imbedded in a dimly shaded or granular substance; they give to the ganglia and to certain parts of the brain and spinal cord the peculiar greyish or reddish-grey aspect by which these parts are characterised.

They are large nucleated cells, filled with a finely granular material, some of which is often dark like pigment: the nucleus, which is vesicular, contains a nucleolus. (fig 33 Kölles. Ts Todd)

Besides varying much in shape, partly in consequence of mutual pressure, they present such other varieties as make it probable either that there are two different kinds, or that, in the stages of their development, they pass through very different forms. Some of them are small, generally spherical or ovoid, and have a regular uninterrupted outline. (Figs above.)

These simple nerve-corpuscles are most numerous in the sympathetic ganglia. Others, which are called caudate or clubbate nerve corpuscles (fig. are larger, and have one, two, (34 Kikes. 55.56. Todd or more long processes issuing from them, which processes often divide and subdivide, and appear tubular, and filled with the same kind of granular material as is contained within the corpuscle. Of these processes some appear to taper to a point, and terminate at a greater or less distance from the corpuscle; others may be traced until each of them, gradually losing its granular appearance, becomes continuous with, and acquires all the characters of, a perfect nerve-fibre. (fig 35 Kikes)

It is probable that the majority of nerve-fibres, when they enter a nervous centre, terminate, or, perhaps, more correctly, originate in this mode of connection with nerve corpuscles. As they enter, the fibres gradually become finer: some, possibly, form single loops; but the majority enter into connection with nerve corpuscles. In the most common form of such connection, the outer substance of the fibre gradually disappears, the pellucid membranous sheath dilates, so as to envelope a nerve-corpuscle which occupies the dilated part; the sheath again contracts, and then, unless the fibre thus ends in the corpuscle (as at A fig 35 Kikes), its sheath is continued over to the other side of the corpuscle, and is gradually filled again with its proper substance. (fig 35. B.)

A prolongation of the granular substance of the carpuscle which thus appears to be inserted or received within the sheath of the fibre, extends for some distance along each part of the nerve tube, taking the place of part of the proper substance of the fibre.

Among the many questions yet to be decided on this subject of the connection of nerve-fibres with the carpuscles in the nervous centres, the principal are whether, in each centre, many fibres thus arise from carpuscles, or whether the carpuscles are more generally inserted in the course of fibres that have some other mode of termination. In several instances more fibres have been counted leaving than entering a ganglion; the surplus therefore, may be supposed to arise from the ganglion carpuscles. It is, also, still to be determined whether this relation to ganglion carpuscles is common to all kinds of nerve-fibres, or limited to those of certain functions. It does not belong exclusively to either the cerebro-spinal or the sympathetic nerves, for it has been seen in the spinal cord as well as in the sympathetic ganglia. Both large and small nerve-fibres also, have been seen to issue from the carpuscles, and Wagner and Bidder mention having several times observed a fibre of both kinds arising from the same carpuscle. They are of opinion that sensitive fibres alone are brought into

this intimate relation with nerve-corpuscles, but the evidence for believing that the motor fibres have not a similar relation, is insufficient.

The Cerebro Spinal fluid. This fluid fills the sub-arachnoid space during life, and keeps the opposed surfaces of the arachnoid mem: in intimate contact. Its quantity, which varies between 2 & 10 ounces, is in the inverse ratio of the bulk of the brain and spinal cord. Thus it is most abundant in old persons in whom these organs have shrunk and it accumulates in cases of deficiency of any portion of them from malformation or disease. Its presence seems necessary to the healthy action of the nervous centres, for the removal of it in dogs by Magendie caused considerable disturbance of their functions, probably by favouring distension of the blood vessels. It is, however, capable of being regenerated as quickly as the aqueous humour of the eye, and its reproduction restores the nervous centres to their natural state. When removed from the body a few moments after death, this fluid is, according to Magendie, remarkably limpid; has a acidly odour and a salticl taste, & is alkaline.

This fluid is most probably secreted by the pia mater, since it is found wherever that membrane and sufficient space exist.

The ventricles of the brain contain a secretion very similar, if not identical in character.

The cerebro-spinal fluid obviously affords mechanical protection to the nervous centres which it surrounds. Its accumulation at the base of the brain is highly favourable for the protection of the large vessels and nerves situated there.

Physical and Chemical Properties of Nervous Matter.

The nervous matter of both kinds is a soft, semifluous substance, easily disturbed by slight mechanical force. Its physical tenacity would be very feeble, were it not supported principally by the blood-vessels which ramify among its elements.

Its great softness is due, partly to the large quantity of water it contains, sometimes 3/4 or 4/5 and in many instances 7/8ths of its weight.

According to Vauquelin, whose analysis was made in 1812, the brain is an complex mixture of albumen, fatty matter and water; the last holding in solution, saline & other ingredients common to the brain with other parts of the body.

The following table gives the result of his analysis.

Albumen			7.00
Cerebral fat	Stearine	4.53	5.23
	Elaine	0.70	
Phosphorus			1.50
osmazome			1.12
Acids, Salts, Sulphur			5.15
Water			80.00
			100.00

Vauquelin remarked that the medulla oblongata & medulla spinalis, have the same composition as the brain, but contain a much larger proportion of cerebral fat, with less albumen, osmazone, & water.

These results are confirmed, in the main, by the analysis of Fremy, in Annales de chimie for 1841. He states that the 3 principal constituents previously detected by Vauquelin, exist in following proportions in 100 parts:

7 parts albumen, 5 parts fatty matter & 80 of water.

From the fatty matter of the brain M. Fremy extracts the following secondary organic compounds:—

1. Cerebric acid; a white substance in the form of crystalline grains, abounding in carbon, and containing minute proportion of phosphorus.

2. Cholesterine, the same as obtained from bile. In preparations of the brain preserved in spirits a substance of a crystalline character resembling cholesterine is apt to form round the piece.

3. Oleophosphoric acid; a peculiar fatty acid containing 1.9 to 2 % of Phosphorus in condition of phosphoric acid. Fremy regards it as analogous to the compound of Sulphuric acid & elaine or, sulph-oleic acid.

4. Traces of elaine, margarine & fatty acids.

These do not always exist in an isolated state.

The quantity of phosphorus which may be found in the nervous matter varies considerably at different periods of life, and is very small in idiotcy. According to L'Heretier's analyses, the minimum of this element is found in infancy in old age, and in idiotcy; and the maximum of water exists in the infant. The following is a table of his comparative analyses:

	Infants	Youth	Adults	Oldmen	Idiots
Albumen	7.00	10.20	9.40	8.65	8.40
Cerebral fat	3.45	5.30	6.10	4.32	5.00
Phosphorus	0.80	1.65	1.80	1.00	0.85
Osmazome & Salts	5.96	8.59	10.19	12.18	14.82
Water	82.79	74.26	72.51	73.85	70.93
	100.00	100.00	100.00	100.00	100.00

A careful comparative analysis of the vesicular and fibrous matter is yet a desideratum. We are ignorant of the nature of the colouring matter of the former.

Functions of Nerve-fibres and Nervous Centres.

G. D. Gibb M.D.

21st Decem 1857

Functions of Nerve-Fibres.

The office of the nerves as simple conveyors or conductors of nervous impressions is of a two-fold kind. First, they serve to convey to the nervous centres the impressions made upon their peripheral extremities, or parts of their course; & in this way the mind, through the medium of the brain, may become conscious of external objects.

Secondly, they serve to transmit impressions from the brain and other nervous centres to the parts to which the nerves are distributed; and these impressions seem to be of at least 2 kinds, those, namely, which excite muscular contractions, and those which influence the secretion, nutrition & other organic functions of a part.

For this two-fold office of the nerves two distinct sets of nerve-fibres are provided, in both the cerebro-spinal and sympathetic systems. Those which convey impressions from the periphery to the centre are classed together as centripetal or afferent nerves, or when speaking exclusively of cerebro-spinal nerves, nerves of sensation, or sensitive nerves. Those fibres, on the other hand, which are employed to transmit central impulses to the muscles are classed as centrifugal, efferent, or motor nerves, or nerves of motion.

The nervous influence by which secretion and nutrition are controlled seems to be conveyed along both sensitive and motive sympathetic nerves.

With this difference in the functions of nerves, there is no apparent difference in the structure of the nerve-fibres by which it might be explained. Among the cerebro-spinal nerves the fibres of the olfactory, optic, and auditory nerves are finer than those of the nerves of common sensation, and more like the fibres in the brain: but with these exceptions no centripetal or sensitive nerve fibres can be distinguished in their microscopic or general characters from those of motor nerves. Neither can the difference in functions be due to the kind of tissue to which a nerve is distributed, for although the nerves supplying muscles are principally motor, yet the muscular tissue contains sensitive fibres also, for pain is felt when it is injured.

The Generation of Force in Nerve-fibres.

Nerve fibres appear to possess no power of generating force in themselves, or of originating impulses to action: for the manifestation of their peculiar endowments they require to be stimulated. They possess a certain property of conducting impressions, a property which has been named excitability; but this is never manifested till some stimulus is applied.

Under ordinary circumstances nerves of sensation are stimulated by external objects acting upon their extremities; and the nerves of motion by the will, or by some force generated in the nervous centres. But almost all things that can disturb the nerves from their passive state act as stimuli, and agents the most dissimilar produce the same kind, though not the same degree of effect, because that on which they act possesses but one kind of excitable force. Thus all stimuli, as well the internal organic as the inorganic, — the chemical mechanical, and electric, — when applied to parts endowed with sensation, or to sensitive nerves (the connection of the latter with the brain and spinal cord being uninjured) produce sensations; and when applied to the nerves of muscles excite contractions. Muscular contraction is produced as well when the motor nerve is still in connection with the brain, as when its communication with the nervous centres is cut off by dividing it; nerves, therefore, have by virtue of their excitability the property of exciting contractions in muscles to which they are distributed; and the part of the divided motor nerve which is connected with the muscle, will still retain this power, however much we may curtail it; but irritation of the other portion, which is in connection with the brain, never excites contractions of the muscles.

Mechanical irritation, when so violent as to injure the texture of the primitive nerve fibres, deprives the centripetal or sensitive nerves of their power of producing sensations when irritation is again applied at a point more distant from the brain than the injured spot; and in the same way, no irritation of a motor nerve will excite contraction of the muscle to which it is distributed, if the nerve has been compressed and bruised between the point of irritation and the muscle; the effect of such an injury being the same as that of division.

Temperature also excites the action of nerves. Thus when heat is applied to the nerve going to a muscle, or to the muscle itself, contractions are produced. These contractions are very violent when the flame of a candle is applied to the nerve. The application of cold has the same effect as heat.

Chemical Stimuli excite the action of both sensitive and motor nerves as mechanical irritants do; provided their effect is not so strong as to destroy the structure of the nerve to which they are applied. A like manifestation of nervous power is produced by electricity and by magnetism.

Transmission of impressions along nervous fibres.

It is a law of action in all nerve-fibres, and corresponds with the continuity and simplicity of their course, that an impression made on any fibre

is simply and uninterruptedly transmitted along it, without being imparted or diffused to any of the fibres lying near it. In other words, all nerve fibres are mere Conductors of impressions. This is due, probably, to the contents of each fibre being completely isolated from those of adjacent fibres by the membrane or sheath in which each is enclosed, and which acts, it may be supposed, just as silk or other non conductors of electricity, when covering a wire, prevent the electric condition of the wire from being conducted into the surrounding medium.

Nervous force travels along nerve fibres with an immeasurable velocity. A certain period of time probably does elapse in the transit of an impression from one end of a fibre to the other; but its length is inappreciable, and will probably never be ascertained, while we have not the opportunity of tracing the passage thro distances as vast as those thro which the passage of light is calculated. It has been supposed, indeed, that the velocity is less in some persons than in others; chiefly because the impression of an object on the retina is sometimes perceived rather later by one person than by another — the difference amounting to one-third, or one-half, or even a whole second.

No nerve fibre can convey more than one kind of impression.

Thus a motor nerve can convey only motor impulses, that is, such as may produce movements in contractile parts: a sensitive fibre can transmit none but such as may produce sensation if they are propagated to the brain. Moreover the fibres of a nerve of special sense, as the optic or auditory, can convey only such impressions as may produce a peculiar sensation, e.g. that of light or sound. While the rays of light, and the sonorous vibrations of the air, are without influence on the nerves of common sensation, the other stimuli, which may produce pain when applied to them, produce, when applied to these nerves of special sense, only marked sensations of light, or sound, or taste, according to the nerve impressed.

Of the Laws of action peculiar to nerves of sensation and of motion respectively, many can be ascertained only by experiments on the roots of the nerves. For, it is only at their origin that the nerves of sensation and of motion are distinct; their filaments, shortly after their departure from the nervous centres, are mingled together, so that nearly all nerves, except those of the special senses, consist of both sensitive and motor filaments, and are hence termed mixed nerves.

Among the laws of action of nerves of sensation is,

1st, that these nerves appear able to convey impressions only from the parts in which they are distributed, towards the nervous centre from which they arise, or to which they tend. Thus when a sensitive nerve, is divided, and irritation is applied to the end of the proximal portion, i.e., of the portion still connected with the nervous centre, sensation is perceived, or a reflex action ensues; but, when the end of the distal portion of the nerve divided is irritated, no effect appears.

When the whole trunk of the nerve is irritated the sensation is felt at all the parts which nerve branches from it: but, when only individual portions up the trunk are irritated, the sensation is perceived at those parts only which are supplied by the several portions.

Thus, if we compress the ulnar nerve where it lies at the inner side of the elbow joint, behind the internal condyle, we have the sensation of "pins and needles", or of a shock, in the parts to which its fibres are distributed; namely, in the palm and back of the hand, and in the 5th and ulnar half of the 4th finger. When stronger pressure is made, the sensations, the sensations are felt in the fore-arm also; and, if the mode & direction of the pressure be varied, the sensation is felt by turns in the 4th finger, in the 5th, in

the palm of the hand, or in the back of the hand, according as different fibres or fasciculi of fibres are more pressed upon than others.

It is in accordance with this law, that when parts are deprived of sensibility by compression or division of the nerve supplying them, irritation of the portion of the nerve connected with the brain still excites sensations which are felt as if derived from the parts to which the peripheral extremities of the nerve-fibres are distributed. Thus, there are cases of paralysis in which the limbs are totally insensible to external stimuli, yet are the seat of most violent pain, resulting, apparently, from irritation of the sound part of the trunk of the nerve still in connection with the brain, or from irritation of those parts of the nervous centre from which the sensitive nerve or nerves supplying the paralysed limbs originate.

The habit of the mind to refer impressions received thro the sensitive nerves to the parts from which impressions through these nerves are, or more commonly received, is further exemplified when the relative position of the peripheral extremities of sensitive nerves is changed artificially, as in the transposition of portions of skin. Thus in the formation of a new nose, the flap

forming the nose has as long as its connection with the forehead remains undivided, the same sensations as if it were still on the forehead. In other words the patient feels when the nose is touched, the impression as if it were derived from the forehead.

When in a part of the body which receives 2 sensitive nerves, one is paralysed, the other is inadequate to maintain the sensibility of the entire part; the extent to which the sensibility is preserved corresponds to the number of the fibres unaffected by the paralysis. This is a consequence of the isolation and simplicity of the several nerve-fibres, so that, as already observed, even when nerves appear to anastomose, their fibres2 seminal continue separate and distinct, as isolated conductors of impressions. Thus, when the ulnar nerve, which supplies the 5th and apart of the 4th finger is divided, the sensibility of those parts is not supplied thro the medium of the branches which the ulnar nerve derives from the median; but the 4th & 5th fingers are permanently deprived of sensibility.

Several of the laws of action in motor nerves correspond with the foregoing. Thus the motor influence is propagated only in the direction of the fibres going to the muscles; by irritation of a

motor nerve, contractions are excited in all the muscles supplied by the branches given off by the nerve below the point irritated, and in those muscles alone: the muscles supplied by the branches which come off from the nerve at a higher point than that irritated, are never directly excited to contractions. No contraction, for instance, is produced in the frontal muscle by irritating the branches of the facial nerve that ramify upon the face, because that muscle derives its motor nerves from the trunk of the facial previous to these branches. So again, because the isolation of motor nerve-fibres is as complete as that of sensitive ones, the irritation of a part of the fibres, of a motor nerve does not affect the motor power of the whole trunk, but only that of the portion to which the stimulus is applied. And it is because of the same fact that when a motor nerve enters a plexus, and contributes with other nerves to the formation of a nervous trunk proceeding from the plexus, it does not impart motor power to the whole of that trunk, but only retains it isolated in the fibres which form its continuation in the branches of that trunk.

Functions of Nervous Centres.

As I have already observed, the term nervous centre is applied to all those parts of the nervous system which contain ganglion-corpuscles, or vesicular nerve substance, i.e. the brain, spinal cord, and the several ganglia which belong to the cerebro-spinal and the sympathetic systems. Each of these nervous centres has a proper range of functions, the extent of which bears a direct proportion to the number of nerve-fibres that connect it with the various organs of the body, and with other nervous centres; but they all have certain general properties and modes of action common to them as nervous centres.

It is generally regarded as the property of nervous centres, that they originate the impulses by which muscles may be excited to action, & by which the normal functions of organic life may be maintained. Hence, they are often called sources or originators of nervous power or force. But, the instances in which these expressions can be strictly used are few. It is possible that the ganglia of the heart are the spontaneous sources of the nervous force that excites the rythmical contractions; that the medulla oblongata may originate the force exciting the

co-ordinate and adapted acts of the first respirations; and that from the spinal cord is derived the force under which the sphincter ani is held in uniform contraction; but with these exceptions (if they are such) few or no motor impulses proceed spontaneously from the nervous centres. The brain does not issue any, except when itself impressed by the will, or stimulated by an impression from without; neither without such previous impressions do the other nervous centres produce or issue motor impulses. The intestinal ganglia, for example, do not give out the nervous force necessary to the contractions of the intestines except when they receive, through their centripetal or sensitive nerves, the stimuli of substances in the intestinal canal. So, also, the spinal cord; for a decapitated animal lies motionless so long as no irritation is applied to its centripetal nerves, though the moment it is touched movements ensue.

The more certain and general office of all the nervous centres is that of variously disposing and transferring the impressions that reach them through their sensual centripetal nerve-fibres. In nerve fibres, as already said, impressions are only conducted in the simple isolated course of the fibre: in all the nervous centres an impression may be not only conducted, but also communicated: in the brain alone it may be perceived.

Conduction in or through nervous centres, is simply illustrated in the food in a given portion of the intestines acting as a stimulus, producing a certain impression on the nerves in the mucous membrane which impression is conveyed thro them to the adjacent ganglia of the sympathetic.

But instead of being conducted, impressions made on nervous centres may be communicated from the fibres that brought them, to others; and in this communication may be either transferred, diffused, or reflected.

The transference of impressions may be illustrated by the pain in the knee, which is a common sign of disease of the hip. Here the impression made by the disease on the nerves of the hip-joint is conveyed to the spinal cord; there it is transferred to the central ends or connections of the nerve fibres of the knee joint. Thro these the transferred impression is conducted to the brain, and the mind, referring the sensation to the part from which it usually, through these fibres receives impressions, feels as if the disease and the source of pain were in the knee. At the same time that it is transferred, the primary impression may be also conducted, and in this case, pain is felt in both the hip & the knee.

So not unfrequently, if one touches a small dimple that may be seated on the trunk, a pain

will be felt in as small a ~~part~~ spot on the arm, or some other part of the trunk. Or again when the suns light falls strongly on the eye, a tickling may be felt in the nose, exciting sneezing. In all these cases the primary impression may be conducted as well as transferred.

The diffusion or radiation of impressions is shewn when an impression received at a nervous centre is diffused to many other fibres in the same centre, and produces sensations extending far beyond, or in an indefinite area around, the part from which the primary impression was derived. Hence, as in the former cases, result various kinds of what have been denominated sympathetic sensations. Sometimes ~~both~~ such sensations are referred to almost every part of the body; as in the shock and tingling of the skin produced by some startling noise. Sometimes only the parts immediately surrounding the ~~part~~ point first irritated participate in the effects of the irritation: thus, the aching of a tooth may be accompanied by pain in the adjoining teeth, and in all the surrounding parts of the face; the explanation of such a case being, that the irritation conveyed to the brain by the nerve fibres of the

diseased tooth is radiated to the central ends of adjoining fibres, and that the mind perceives this secondary impression as if it were derived from the peripheral ends of the fibres. Thus also, the pain of a Calculus in the ureter is diffused far & wide.

All the preceding examples represent impressions communicated from one sensitive fibre to others of the same kind; or from fibres of special sense to those of common sensation. A similar communication of impressions from sensitive to motor fibres, constitutes Reflection of Impressions, displays the important function common to all nervous centres as Reflectors, and produces Reflex movements. In the extent and direction of such communications also, phenomena corresponding to those of transference and diffusion to sensitive nerves are observed in the phenomena of reflection. For, as in transference, the reflection may take place from a certain limited set of sensitive nerves, to a corresponding and related set of motor nerves; as when, in consequence of the impression of light on the retina, the iris contracts, but no other muscle moves. Or, as in diffusion or radiation, the reflection may bring widely extended muscles into action; as when the irritation in the larynx brings all the muscles engaged in expiration into coincident movement.

The most general rules of reflex action.

1. For the manifestation of any reflex action, 3 things are necessary: first, one or more centripetal or sensitive nerve fibres, to convey an impression. 2ndly, a nervous centre to which this impression may be conveyed, & in which it may be reflected. 3rdly, one or more centrifugal or motor nerve fibres, upon which this impression may be reflected, and by which it may be conducted to the contracting tissue.

In the absence of either of these 3 conditions, a proper reflex movement could not take place; and whenever impressions made by external stimuli or sensitive nerves give rise to motions, these are never the result of the direct reaction of the sensitive and motor fibres of the nerves on each other; in all such cases the impression is conveyed by the sensitive fibres to a nervous centre, & is therein communicated to the motor fibres.

2. All reflex actions are essentially involuntary; all may be accomplished independant of the will, though most of them admit of being modified, controlled, or prevented by a voluntary effort. All are perfectly performed without education or previous experience, although some, as coughing and the like, are not well performed unless the will have previously made some preparatory movement.

3. All reflex actions performed in health have a

distinct purpose, and are adapted to secure some end desirable for the well being of the body; but, in disease many of them are irregular and purposeless. As an illustration of the first point may be mentioned movements of the digestive canal, the respiratory movements, the contraction of the eyelids and the pupil to exclude many rays of light when the retina is exposed to a bright glare. These, and all other normal reflex acts afford, also, examples of the mode in which the nervous centres combine and arrange coordinately the actions of the nerve-fibres, so that many muscles may act together for the common end. Another instance of the same kind is furnished by the spasmodic contractions of the glottis on the contact of carbonic acid, or any foreign substance, with the internal surface of the epiglottis or larynx. Examples of the purposeless, irregular nature of morbid reflex actions are seen in the convulsive movements of epilepsy, and in the spasms of tetanus and hydrophobia.

4. Reflex muscular acts are more commonly sustained than those produced by the direct stimulus of muscular nerves. As Valkmann states, the irritation of a muscular organ, or its motor nerve, produces contraction lasting only so long as the irritation continues; but irritation applied to a nervous centre thro one of its centripetal or sensitive nerves excites reflex and harmonious contractions, which last some time after the withdrawal of the stimulus.

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Spinal Cord
and its nerves.

G D Gibb M D

24th Decem 1851

To illustrate

Spinal cord sections fig 66. 67 Todd

Fennichs Carpenter fig 16. p. 126.

Boerhaves Physiology plate 23

Cerebro-Spinal Nervous System.

The physiology of the cerebro-spinal nervous system includes that of the spinal cord, medulla oblongata and brain, of the several nerves given off from each, and of the ganglia on those nerves.

We shall first consider the spinal cord and its nerves.

Spinal Cord and its nerves.

The spinal cord is a cylindriform column of nervous matter, slightly flattened anteriorly and posteriorly, connected above with the brain through the medium of the medulla oblongata, terminating below, about the 1st or 2nd lumbar vertebra, in a slender filament of grey or vesicular substance, the filum terminale, which lies in the midst of the roots of many nerves forming the cauda equina.

Superiorly the spinal cord is separated from the medulla oblongata by the decussating fibres of the anterior pyramids. The cord is composed of fibrous and vesicular nervous substance, of which the former is situated externally, and constitutes its chief portion, while the latter occupies its central or axial portion, and is so arranged that on the surface of a transverse section of the

cord it appears like 2 somewhat crescentic masses connected together by a narrower portion, or isthmus.

Show figs of spinal cord. Tract &c.

The spinal cord consists of 2 halves, perfectly and exactly symmetrical, united in the middle line by a commissure, but separated anteriorly and posteriorly by a vertical fissure; the posterior fissure is deeper, but not so wide and distinct as the anterior. Each half of the spinal cord is marked on the sides (obscurely at the lower part but distinctly above,) by 2 longitudinal furrows, which divide it into 3 portions, columns, or tracts, an anterior, middle or lateral, and posterior.

~~The partitions~~ From the groove between the anterior and lateral columns spring the anterior roots of the spinal nerves; and just in front of the groove between the lateral and posterior columns arise the posterior roots of the same: a pair of roots on each side corresponding to each vertebra.

The fibrous part of the cord contains continuations of the numerous fibres of the spinal nerves issuing from it, or entering it; but it is probably not formed of them exclusively; nor of a mere trunk, like a great nerve, through which they may pass to the brain. It is indeed, among the most difficult things in structural anatomy to determine the course of individual nerve fibres through even a short distance of the spinal

cord: yet it appears nearly sure that most or all of the fibres of the roots of the spinal nerves terminate in some part of the cord near that in which they first appear connected with it, and do not proceed through it in simple and uninterrupted continuity to the brain. The majority of these fibres, when traced into the cord from the roots of the nerves, appear to pass in a longitudinal direction; and the substance of the cord, after being hardened in spirit, admits of being broken up into longitudinal laminae, and cannot without much force be split obliquely or transversely. But the distances to which the fibres composing the laminae run longitudinally from their entrance into the cord is unknown, and probably, by such means as we at present possess, is not determinable. But that they do not pass upto the brain is probable rendered by several circumstances. Kirkes & Paget p. 378.

The nerves of the spinal cord consist of 31 pairs, issuing from the sides of the whole length of the cord; their numbers corresponding with the intervertebral foramina thro which they pass. Each nerve arises by 2 roots, an anterior and a posterior, the latter being the largest. The roots emerge through separate apertures of the sheath of dura mater surrounding the cord; and directly after their emergence, while the roots lie in the intervertebral foramen, a ganglion is formed

or the posterior root. The anterior root lies in contact with the anterior surface of the ganglion, but none of its fibres intermingle with those in the ganglion. But immediately beyond the ganglion, the 2 roots coalesce, and, by the mingling of their fibres, form a compound or mixed spinal nerve, which after issuing from the intervertebral canal, divides into an anterior and posterior branch, each containing fibres from both the roots.

The anterior root of each spinal nerve arises by numerous separate and converging fasciculi from the anterior column of the cord; the posterior root by more numerous parallel fasciculi, from the posterior column, or rather, from the posterior part of the lateral column; for if a fissure be directed inwards from the groove between the middle and posterior columns, the posterior roots will remain attached to the former.

The anterior roots of each spinal nerve consist, exclusively, of motor fibres; the posterior as exclusively of sensitive fibres. For the knowledge of this important fact, and much of the consequent progress of the physiology of the nervous system, science is indebted to Sir Charles Bell. It is proved in various ways. Division of the ~~posterior~~ anterior roots of one or more nerves is followed by complete loss of motion in the parts supplied by the fibres of such roots; but the sensation of the same parts remains perfect.

Division of the posterior roots destroys the sensibility of the parts supplied by their fibres, while the power of motion continues unimpaired. Moreover, irritation of the ends of the distal portions of the divided anterior roots of a nerve excites muscular movements; irritation of the ends of the proximal portions, which are still in connection with the cord, are followed by no effect. Irritation of the distal portions of the divided posterior roots, on the other hand, produces no muscular movements, and no manifestation of pain; for, as already stated, sensitive nerves convey impressions only towards the nervous centres: but irritation of the proximal portions of these roots elicit signs of intense suffering. Occasionally, also, under this last irritation, muscular movements ensue; but these are either voluntary, or the result of the irritation being reflected from the sensitive to the motor fibres.

As an example of the experiments of which I have given a summary account, the following may be related: If in a frog, the 3 posterior roots of the nerves going to the hinder extremity be divided on the left side, and the 3 anterior roots of the corresponding nerves on the right side, the left extremity will be deprived of sensation, the right of motion. If the foot of the right leg, which is still endowed with sensation but not with the power of motion, be cut off, the

frog will give evidence of feeling pain by movements of all parts of the body except the right leg itself, in which he feels the pain. If on the contrary, the foot of the left leg which has the power of motion, but is deprived of sensation, is cut off, the frog does not feel it, and no movement follows except the twitching of the muscles irritated by cutting them or their tendons.

Functions of the Spinal Cord.

The spinal cord manifests all the properties which have been already assigned to the nervous-centres.

1. It is capable of conducting impressions, or states of nervous excitement. Through it, all the impressions made upon the peripheral extremities or other parts of the spinal sensitive nerves are conducted to the brain, or here alone they can be perceived by the mind. Through it, also, the stimulus of the will, applied to the brain, is capable of exciting the action of the muscles supplied from it with motor nerves. And for all these conductions of impressions to and fro between the brain and the spinal nerves, the perfect state of the cord is necessary; for when any part of it is destroyed, and its communication with the brain is interrupted, impressions

on the sensitive nerves given off from it below the seat of injury, cease to be propagated to the brain; and the mind loses the power of voluntarily exciting the motor nerves proceeding from the portion of cord isolated from the brain.

Illustrations of this are furnished by various examples of paralysis, but by none better than by the common paraplegia, or loss of sensation and voluntary motion in the lower part of the body, in consequence of destructive disease or injury of a portion, including the whole thickness, of the spinal cord. Such lesions destroy the communication between the brain and all parts of the spinal cord below the seat of injury, and consequently cut off from their connection with the mind, the various organs supplied with nerves issuing from those parts of the cord. But, if this lower portion of the cord preserves its integrity, the various parts of the body supplied with nerves from it, though cut off from the brain, will nevertheless be subject to the influence of the cord, and as I shall presently show you, will indicate its other powers as a nervous centre.

From what has been said, it will appear probable that the conduction of impressions along the cord is effected (at least for a part of the distance) through the grey substance, i.e. through the nerve corpuscles and filaments connecting them. But there is reason to believe that all parts of the

cord are not alike able to conduct all impressions; and that, rather, as there are separate nerve fibres for motor and for sensitive impressions, so, in the cord, separate and determinate parts serve to conduct the same impressions. The consideration of this point involves the question of the functions of the columns of the cord. The question is whether the anterior and posterior columns correspond to the anterior and posterior roots respectively; whether the anterior columns contain only motor, the posterior only sensitive fibres. It was difficult to decide this, even when it was supposed that the fibres of the roots of the nerves were continued uninterruptedly to the brain; and the difficulty is much increased if we believe that they are not so continued, and that conduction may take place as well thro the grey substance of the cord as thro its fibres.

Experiments of Longet and Van Deen, have shown that irritations of the anterior columns of the spinal cord are followed by convulsive movements of all the parts supplied with motor nerves from and below the irritated part, but give rise to no manifestations of pain: while irritation of the posterior columns appears to cause excruciating pain, without producing any muscular movement besides such as may be the result of volition, or the reflection of the stimulus from the irritated cord to the roots of the motor nerves. Again, when the spinal

cord is completely divided, irritation of the posterior columns of the lower part, which is cut off from the brain, produces no effect: irritation of the anterior columns of the same part excites violent movements. And, in the same experiment, irritation of the divided anterior columns of the portion of the cord still connected with the brain produces no effect; but irritation of the divided posterior columns of the same portion produces acute pain and reflex movements. (Longet.)

Again, when both the anterior columns of the cord are divided, the power of voluntary movement over the parts supplied with nerves below the point of division is completely lost: the sensibility of the same parts being unimpaired. When both posterior columns are divided, sensation in the parts supplied by nerves from below the injured point is lost, while the power of movement over such parts remains perfect. (Van Deen).

The results of these experiments would seem to prove that the effects of the division of the anterior or posterior columns of the cord are exactly the same as those of division of the anterior or posterior roots of the spinal nerves, and that therefore one might be justified in calling the anterior the motor, and the posterior the sensitive columns of the cord.

All these observations have related only to the conduction of impressions along the cord; they

* paralysis of motion ~~in~~ in the right lower extremity, and incomplete paralysis of motion in the right upper extremity, but sensibility was perfect.

may also be conducted in some direction across it. Thus, if the brain and medulla oblongata be removed, irritation of either posterior columns of the upper end of the cord will cause general movements of muscles, the impression being conveyed across to the anterior columns and roots; for the movements do not happen if the anterior roots are divided. If one half of the cord be divided at a certain part, and the other half at a certain distance from that part, impressions (at least, sensitive ones) may be conducted thro the intermediate portion of the cord from one side to the other (Van Deen); and this may be effected though only a portion of the grey substance be left to connect the portions of cord above and below. But impressions do not seem to be conveyed from the anterior columns to the posterior, nor from one anterior column to the other; so that, as in the case I shall cite from Begin, after the division of one anterior column, including the anterior part of the grey matter in it, the will has no power over the muscles deriving nerves from or below the injured part of the column.

Begins case. A man was stabbed at the back of the neck, and the point of the knife passed obliquely forwards between the 6th & 7th cervical vertebrae, dividing the corresponding antero-lateral and anterior columns of the cord on the right side. During the 6 days in which he survived the injury, there existed a complete *

anterior right

2. In the second place, the spinal cord as a nervous centre, or rather as an aggregate of many nervous centres, has the power of communicating impressions from fibre to fibre in the several ways already mentioned in my last lecture, on the functions of the nervous centres.

Examples of the transference and radiation of impressions in the cord have been given; and that the transference at least takes place in the cord, and not in the brain, is nearly proved by the cases of pain felt in the knee, and not in the hip, in diseases of the hip; of pain felt in the urethra or glans penis, and not in the bladder, in calculus; for, if both the primary, and the secondary or transferred, impressions, were in the brain, both should be always felt. Of radiation of impressions there are, perhaps, no means of deciding whether they take place in the spinal cord or in the brain: but the analogy of the cases of transference makes it probable that the communication is, in this, also, effected in the cord.

The power, as a nervous centre, of communicating impressions from sensitive to motor, or, more strictly, from centripetal to centrifugal nerve-fibres; what is usually discussed as the

reflex function of the spinal cord.

Lb

its general mode of action, its general, though incomplete, independance of consciousness, the will, and the brain, and the conditions necessary for its perfection have been stated in my last lecture. These points, and the extent in which the power operates in the production of the natural reflex movements of the body, will now be further illustrated. They will be described in terms adapted to the general rules of reflection of impressions in nervous centres, avoiding all such terms as might seem to imply, that the power of the spinal cord in reflecting is different in kind from that of all other nervous centres.

The occurrence of movements under the influence of the spinal cord, and independant of the will, is shown in the acts of swallowing, when food is carried by voluntary efforts into the fauces, & is conveyed by involuntary successive contractions of the constrictors of the pharynx and muscular walls of the oesophagus into the stomach. These contractions are excited by the stimulus of the food on the centripetal or sensitive nerves of the pharynx and oesophagus being first conducted to the spinal cord & med: oblong: and thence reflected thro the motor nerves to these parts. All these movements of phar: & oesoph: are involuntary; the will cannot arrest or modify them.

so also, under the influence of the spinal cord is the sphincter ani, maintained in the involuntary and unfelt muscular contraction, when the mind is inactive, as in deep sleep, but ceases when lower part of cord is destroyed, & cannot be maintained by the will.

The independance of the mind manifested by the reflecting power of the cord, is further shewn in the more perfect occurrence of the reflex movements when the spinal cord and brain are disconnected, as in decapitated animals, and in cases of injuries or diseases so affecting the spinal cord as to divide or disorganize its whole thickness at any part whose perfection is not essential to life.

The proper reflex acts, performed under the influence of the ~~existe~~ reflecting power of the spinal cord, are essentially independant of the brain, and may be performed perfectly when the brain is separated from the cord: that these include a much larger number of the natural and purposive movements of the lower animals than of the warm-blooded animals and man; and that over nearly all of them the mind may exercise, through the brain, some control; determining, directing, hindering, or modifying them, either by direct action or by its power over associated muscles.

In this fact, that the reflex movements

from the cord may be perfectly performed without the intervention of consciousness or will, yet are amenable to the control of the will, we may see their admirable adaptation to the well being of the body. Thus, for example, the respiratory movements may be performed while the mind is, in other things, fully occupied, or in sleep powerless; yet, in an emergency, the mind can direct and strengthen them; and it can adapt them to the sexual acts of speech, effort, &c. Being commonly independant of the brain, their constant continuance does not produce weariness; for it is only in the brain that it or any other sensation can be perceived.

The subjection of the muscles to both the spinal cord and the brain makes it difficult to determine in man what movements or what share in any of them can be assigned to the reflecting power of the cord. The fact, that after division or disorganization of a part of the cord, movements, and even forcible though useless ones, are produced in the lower limbs when the skin is irritated, shows that the spinal cord can supply nervous force for the action of the muscles, that are, naturally, most under the control of the will: and it is, therefore, not improbable that, for even the voluntary action of those muscles, when the cord is perfect, it may supply the force, & the will the direction.

For instances in which it supplies both force & direction, that is, both excites and determines the combination of muscles, may be mentioned the acts of the abdominal muscles in vomiting and voiding the contents of the bladder and rectum.

The emission of semen is equally a reflex act governed by the spinal cord: the irritation of the glans penis conducted to the spinal cord, & thence reflected, excites the successive and co-ordinate contractions of the muscular fibres of the vasa deferentia and vesiculae seminales, and of the bulbo-cavernosi and other muscles of the urethra; and a forcible expulsion of semen takes place, over which the mind has little or no control, and which, in cases of paraplegia, may be unfelt. The erection of the penis also, appears to be in part the result of a reflex contraction of the muscles, by which the veins returning the blood from the penis are compressed. Irritation of the vagina in sexual intercourse appears to be also propagated to the spinal cord and thence reflected to the motor nerves supplying the Fallopian tubes. The involuntary action of the Uterus in expelling its contents during parturition, is also of a purely reflex kind, dependant in part upon the spinal Cord, though in part also upon the sympathetic System: its dependance of the brain and the mind is proved by cases of delivery in paraplegic women, and is now more abundantly shewn in the use of Chloroform.

Besides these acts, regularly performed under the reflecting power of the spinal cord, others are manifested in accidents; such as movements of limbs and other parts, to guard the body against the effects of sudden danger.

To these instances of spinal reflex action, some add many more, including unconscious acts, such as standing, walking & the like. But these are not involuntary acts; they are not accomplished without the active co-operation of the brain, for they are impossible in coma, sleep, paraplegia, & complete mental abstraction; they all require education for their perfection.

Reflex actions in disease. The phenomena of spinal reflex actions in man are much more striking and unmixed in cases of disease. In some of these, the effect of a marked irritation of the cord, is very simple; as when the local irritation of sensitive fibres, being propagated to the spinal cord, excites merely local spasms, — spasms, namely, of those muscles, the motor fibres of which arise from the same part of the spinal cord as the sensitive fibres that are irritated. Of such a case we have instances in the spasms and tremors of limbs, in severe burns.

In other instances, when the cord is very irritable indeed, as in tetanus the slightest touch on the skin may throw the whole body in convulsions.

a similar state is induced by the introduction of strichnia, and in frogs of opium, into the blood; and numerous experiments on frogs thus made tetanic have shown that the tetanus is wholly unconnected with the brain, and depends on the state induced in the spinal cord.

It may have seemed to be implied that the spinal cord as a single nervous centre, reflects alike from all parts, all the impressions conducted to it. But it is more probable that it should be regarded as a collection of nervous centres united in a continuous column. This is rendered probable by the fact that segments of the cord may act as distinct nervous centres, and excite motions in the parts supplied with nerves given off from them; as well as by the analogy of certain cases in which the muscular movements of single organs are under the control of certain circumscribed portions of the cord, as instanced in Valentin's experiments on the lymphatic heart of frogs. Kirkes p 394.

It might be supposed that each portion of the cord is as the nervous centre of a certain region, receiving & issuing impressions from & to the dorsal nerve fibres immediately connected with it. But some experiments of Engelhardt and Harless have made it probable (if the case of frogs may be taken as an example of general truth), that different portions of the

length of the cord are assigned for the govern-
ment of different kinds of movements.

The influence of the spinal cord on the
Sphincter ani I have already mentioned. (p. 13)
It maintains this muscle in permanent contrac-
tion, so that, except in the act of defecation, the
orifice of the anus is always closed. This
influence of the cord resembles its common reflex
action in being involuntary, although the will
can act on the muscle to make it contract more,
or to permit its dilatation, and in that the
constant action of the muscle is not felt, nor
diminished in sleep, nor productive of fatigue.
But the act is different from ordinary reflex acts
in being nearly constant. In this respect it resembles
that condition of muscles which has been called
Tone, or passive contraction, a state in which
they always appear to be when not active in health,
and in which, though called inactive, they appear
to lie in slight contraction, and certainly are
not relaxed, as they are long after death, or
when the spinal cord is destroyed. This tone
of all the muscles of the trunk and limbs seems
to depend on the spinal cord, as the contraction
of the sphincter ani does. If an animal is
killed by injury or removal of the brain, the
tone of the muscles may be left, and the limbs

feel firm as during sleep; but if the spinal cord be destroyed, the sphincters are relaxes, and all the muscles feel loose, and flabby, and atonic, and remain so till the rigor mortis commences.

31

Medulla Oblongata and Pons Varolii.

G. Gibb M.D.

27th Decem 1851

To illustrate

Todd. fig 68. 69. 70.

Medulla Oblongata.

Its structure. The medulla oblongata is a mass of grey and white nervous matter contained within the cavity of the cranium, forming part of the cephalic prolongation of the spinal cord, and connecting it with the brain. It is truly "the link which binds us to life". In form and general anatomical characters, it very much resembles the spinal cord, with which it is continuous, standing in the same relation to it, as the capital to the shaft of a column. It is completely contained within the cranial cavity, its lowest part being just above the level of the plane of the occipital foramen. In size it is much larger in some of the lower animals than in man, in many of them it forms the largest of all the segments of the encephalon, while in man it is much the smallest.

The grey substance which it contains is situated in the interior, variously divided into masses and laminae by the white or fibrous substance, which is arranged partly in external columns, and partly in fasciculi traversing the central grey matter. The medulla oblongata is larger than any part of the spinal cord. Its columns are pyriform, enlarging as they proceed towards the brain, continuous with

a named from resemblance in shape to an alene.

with those of the spinal cord, more prominent than they are, and separated from one another by deeper grooves. In front are two, corresponding with the anterior columns of the cord, and named anterior pyramids, or corpora pyramidalia; they are separated from each other by a deep anterior median fissure, at the bottom of which fibres appear decussating, i.e. crossing one another and changing sides.* In this manner, nearly all the fibres of each pyramid pass over, and turning backwards become continuous with the opposite lateral columns of the cord; those which do not decussate are directly continuous with the anterior column of the cord. Traced upwards, the fibres of the anterior pyramids pass through the inferior part of the pons Varolii and then, forming the lower part of the crura cerebri, proceed through the optic thalami and corpora striata to be distributed in the substance of the cerebral hemispheres. (Todd fig 68.)

External to each anterior pyramid is a prominent oval body (the olivary body[a]), surrounded by a superficial groove, which in some instances is partially interrupted by some arciform fibres which cross it at its lower part. The fibres in

* These fibres are called the decussating fibres of the anterior pyramids, and form, very fitly, an anatomical demarcation between the medulla oblongata and spinal cord.

b. restis, a rope.

and around the olivary body are continuous below with those of the corresponding anterior tracts of the cord, while above they pass into the deeper longitudinal fibres of the medulla oblongata, along which they may be traced through the crura cerebri into the lower parts of the optic thalami and corpora striata. The corpora olivaria are formed of portions of grey substance imbedded in fibres, and elevating them.

Immediately behind the corpora olivaria, on each side, is a small depressed tract of fibrous matter, distinguished from the olivary tract because its fibres, instead of passing onwards longitudinally to the cerebrum, go outwards transversely through the pons into the cerebellum. These tracts are named the lateral tracts, and are interesting in that the facial nerve emerges through them, and probably derives from them its connection with the motor portion of the medulla oblongata and cord.

Behind the lateral tract on each side, is the corpus restiforme, a large column of nerve fibres, which, with its continued fibres below, forms the restiform tract. The restiform bodies form the greatest part of the posterior, as well as the lateral portion of the medulla oblongata, they are separated from each other along the middle line by 2 slender columns,

the posterior pyramids. These last bound the posterior fissure. The restiform tract is continuous below with the posterior columns of the cord, while above, its fibres may be traced transversely through the pons into the cerebellum. Those of each body form a large portion of the corresponding crus cerebelli, and are distributed to the corresponding hemisphere of the cerebellum, whence it is probable that continuations from them pass into the cerebrum.

As just mentioned the restiform bodies are separated from each other posteriorly by 2 narrow columns, the posterior pyramids, or posterior pyramidal tracts, one on each side of the posterior fissure; and by the lower angle of the fourth ventricle. The fibres of these tracts are continuous below with a narrow column which about the middle portion of the cervical portion of the cord begins to be, as it were, set off from the posterior columns by a narrow groove. They seem to pass upwards longitudinally through the pons, and thence in connection with the processes that unite the cerebrum with the cerebellum, under the corpora quadrigemina, and into the crus cerebri of the opposite side. (fig 69 of Todd)

Deeper than the internal pyramidal tracts, and forming slight elevations on each side of the

middle line of the fourth ventricle, are other two, named the round tracts. They appear to be composed of the middle or axial portions of the anterior and lateral columns, which, as they pass upwards, are, as it were, exposed from behind by the divergence of the restiform and posterior pyramidal tracts. The round tracts pass longitudinally through the pons, and thence proceed, decussating, under the corpora quadrigemina to the fibres of the crura cerebri.

The continuation of the grey matter of the cord into the medulla oblongata forms the grey matter covering the floor of the fourth ventricle, and diffused beneath its surface. The separation of the posterior internal and restiform tracts leaves open, in the fourth ventricle, the upper portion of the canal which, in the early fœtal state, extends through the whole length of the grey matter of the spinal cord, and is continuous above with the cerebral ventricles.

It is unfortunate indeed, that even a much deeper study than what I have just sketched of the anatomy of the medulla oblongata, affords very little insight into its physiology. The interest connected with the tracing of the continuities of its several columns with those of the spinal cord lies, chiefly, in the fact that nerves of similar

function arise from both. Thus, from the anterior pyramids, and their continuation in the crura cerebri, arise the motor third and sixth pairs of cerebral nerves. From the groove between the anterior pyramids and the olivary tracts (a groove continuous with that in which all the motor roots of the spinal nerves emerge) arises the motor hypoglossal nerve. From the lateral and the round tracts, formed of fibres continuous with the anterior and lateral columns of the cord, arise the motor facial, and fourth or trochlear nerves; while from the front of the restiforme tracts in a line continuous with the groove between the posterior and lateral columns of the cord, spring the roots of the sensitive glosso-pharyngeal and pneumogastric nerves.

I shall give the origin of the nerves more minutely when I come to speak of them individually in a future lecture.

There is thus, the closest analogy in structure, and probably also, in the general endowments of their several parts, between the medulla oblongata and the spinal cord. The difference in size and form appears due, chiefly, first, to the divergence, enlargement, and decussation of the several columns, as they pass to be connected with the cerebellum

or the cerebrum; and, secondly, to the insertion of new quantities of grey matter, in the olivary bodies and other parts, in adaptation to the higher office, and wider range of influence, which the medulla oblongata as a nervous centre exercises. (Fig 70. Todd.)

Functions of the Medulla Oblongata.

In its functions, the medulla oblongata differs from the spinal cord chiefly in the importance and extent of the actions that it governs.

Like the cord, it may be regarded first, as Conducting impressions, in which office it has a wider extent of function than any other part of the nervous system, since it is obvious that all impressions passing to and fro between the brain and the spinal cord, and all nerves arising below the pons, must be transmitted thro it. The modes of conduction through the medulla oblongata are probably similar to those through the cord. In the same degree as it is probable that the spinal cord transmits motor impressions in its anterior columns, and sensitive impressions chiefly along its posterior columns, so is it that the medulla oblongata conducts motor impressions along its anterior pyramidal and olivary tracts, and sensitive ones along its

posterior and restiform tracts. This, which might be expected from the continuity of the columns in the 2 parts, and the similarity of the nerves arising from them, is further rendered probable by experiments and the results of disease. Magendie divided one of the anterior pyramidal tracts of the medulla oblongata, and observed complete loss of of the motor power over one half of the body, while its sensation seemed to be unimpaired. In Longets experiments on dogs and rabbits, irritation of the anterior pyramids appeared to be unproductive of pain, but the slightest touch of the restiform bodies, elicited signs of acute suffering.

Among the corresponding evidences furnished by disease, Lebert mentions a case in which great disorder of the power of motion, with unimpaired sensation, resulted from an affection of the anterior portion of the medulla oblongata: the posterior portion being apparently unharmed.

The decussation of part of the fibres of the anterior pyramids of the medulla oblongata, and their crossing into the lateral tracts of the opposite side of the cord, make it probable that the motor impressions proceeding from the brain would, by traversing one pyramid, pass across to the opposite side of the spinal cord. Thus are explained the phenomena of

cross-paralysis, as it is termed, i. e. of the loss of motion, in cerebral apoplexy, being always on the side opposite to that on which the effusion of blood has taken place. But, in the present state of the anatomy of the medulla oblongata, it is not possible to explain why the loss of sensation is also on the side opposite the injury or disease of the brain: for there is no evidence of a decussation of posterior fibres nearly equal to that which ensues among the anterior fibres of the medulla oblongata and upper part of the cord.

The functions of the medulla oblongata as a nervous centre, are more immediately important to the maintainance of life than those of any other part of the nervous system, since from it alone issues the nervous force necessary for the performance of respiration & deglutition.

It has been proved by repeated experiments, especially by those of Legallois, Flourens & Longet, that the entire brain may be gradually cut away in successive portions, and yet life may continue for a considerable time, and the respiratory movements be uninterrupted.

Life may also continue when the the spinal cord is cut away in successive portions from below upwards as high as the point of origin of the phrenic nerve, or in animals without a diaphragm, such as birds or reptiles, even as

high as the medulla oblongata. In Amphibia these 2 experiments have been combined: the brain being all removed from above, and the cord from below; and so long as the medulla oblongata was intact, respiration & life was maintained. But if in any animal, the med: oblon: is wounded, particularly if it is wounded in its central part opposite the origin of the pneumogastric nerves, the respiratory movements cease, and the animal dies as if asphyxiated. And this effect ensues even when all part of the nervous system, except the medulla oblong:, are left intact.

Injury and disease in men prove the same as these experiments on animals. Numerous instances are recorded, especially by Sir Charles Bell, in which injury to the human medul: oblong: has produced instantaneous death; & indeed, it is through injury of it, or of the part of the cord connecting it with the origin of the phrenic nerve, that death is commonly produced in fractures and diseases with sudden displacement of the upper cervical vertebrae.

The centre whence the nervous force for the production of respiratory movements appears to issue, is in the interior of that part of the med: oblong: from which the pneumogastric nerves arise*; for with care the medul: oblong: may be

* Cham Cyc 70 of Todd.

divided to within a few lines of this part, and its exterior may be removed, without the stoppage of respiration; but it immediately ceases when this part is invaded. This is not because the integrity of the pneumogastric nerves is essential to the respiratory movements, for both these nerves may be divided without more immediate effect than a retardation of these movements. The conclusion, therefore, may safely be, that this part of the medul: oblong: is the nervous centre wherein the impulses producing the respiratory movements originate, and whence they issue in rythm and adaptation.

The power by which the med: oblong: governs and combines the action of various muscles for the respiratory movements is an instance of the power of reflection, which it possesses in common with all nervous centres. Its general mode of action, as well as the degree in which the mind may take part in respiration, and the number of nerves and muscles which, under the governance of the med: oblong:, may be combined in the forcible respiratory movements, have been already briefly alluded to. (171 Kidd). That which seems most peculiar in this centre of respiratory action is its wide range of connection, the number of nerves by which the centripetal or sensitive impression to excite motion may be conducted, and the number and distance of those through which the motor impulse may be directed. The principal centripetal nerves engaged in respiration are the

pneumogastric, whose branches supplying the lungs appear to convey the most acute impression of the "necessity of breathing". When they are both divided the respiration according to Dr J Reid becomes slower, as if the necessity were less acutely felt: but it does not cease, and therefore other nerves besides them must have the power of conducting the like impression. The experiments of Valkemann render it probable that all centripetal nerves possess it in some degree, and that the existence of imperfectly aerated blood in contact with any of them acts as a stimulus, which, being conveyed to the med: oblong:, is reflected to the nerves of the respiratory muscles; so that respiratory movements do not wholly cease so long as any centripetal nerves, and any nerves supplying muscles of respiration, are both in continuous connection with the respiratory centre of the medulla oblongata.

The wide extent of connection which belongs to the med: oblong: as the centre for the respiratory movements, is further shown by the fact that impressions, by mechanical and other ordinary stimuli, made on many parts of the external or internal surface of the body, may induce respiratory movements. Thus involuntary inspirations are induced by the sudden contact of cold with any part of the skin, as in dashing cold water into the face; irritation of the muc: mem: of the nose produces sneezing; irritation ~~of~~ in the

pharynx, œsophagus, stomach, or intestines, excites the concurrence of the respiratory movements to produce vomiting; violent irritation in the rectum, bladder, or uterus, gives rise to a concurrent action of the respiratory muscles, so as to effect the expulsion of the fœces, urine, or fœtus.

The Med: oblong: is also the centre whence are derived the motor impulses enabling the muscles of the palate, pharynx, and œsophagus to produce the successive co-ordinate and adapted movements necessary to the act of deglutition. This is proved by the persistence of the power of swallowing after destruction of the cerebral hemispheres and cerebellum; its existence in anencephalous monsters; the power of swallowing possessed by marsupial embryos before the brain is developed; and by the complete arrest of the power of swallowing when the Medul: oblong: is injured in experiments. But the reflecting power herein exercised by the Med: oblong: is of a much simpler and more restricted kind than that exercised in respiration; it is, indeed, not more than a simple instance of reflex action by a segment of the spinal axis, receiving impressions for this purpose from only a few centripetal nerves, & reflecting them to the motor nerves of the same organ. The incident or centripetal nerves in this case are the branches of the glosso-pharyngeal &, in a subordinate degree, those of the cervical nerves, which combine to form the pharyngeal plexus; and the nerves through which the motor impressions

to the fauces and pharynx are reflected are the pharyngeal branches of the vagus, and in subordinate degrees, or as supplying muscles accessary to the movements of the pharynx, the branches of the hypoglossal, facial, cervical, recurrent and fifth nerves. For the oesophageal movements, so far as they are concerned with the med: oblong:, the filaments of the pneumogastric nerve alone appear to be sufficient.

Though respiration and life continue while the med: oblong: is perfect and in connection with respiratory nerves, yet, when all the brain above it is removed, there is no more appearance of sensation, or will, or of any mental act in the animal the subject of the experiment, than there is when only the spinal cord is left. The movements are all involuntary and unfelt; and the med: oblong: has therefore no claim to be considered as an organ of the mind, or as the seat of sensation or voluntary power. There are connected with parts next to be described.

It may hence observed, that the part of the med: oblong: which acts as a nervous centre may continue to discharge its function after the part which is only a conductor has ceased to act. Thus patients with apoplexy or compression of the brain may go on breathing, though, if they have any sensibility or voluntary power,

it is so little, that we cannot suppose any impressions to be conveyed, in either direction, through the med: oblong: And so, when ether or chloroform has been inhaled, patients breathe very well, though they are so wholly insensible, and have so completely lost all voluntary power, that we cannot suppose the med: oblong: to conduct either to or from the pons or any other part of the brain.

Moreover, it appears that by such inhalation much of the reflecting power of the med: oblong: may be destroyed, and yet its power in the respiratory movements may remain. Thus, in patients completely affected with Chloroform, the winking of the eyelids ceases, & irritation of the pharynx will not produce the usual movements of Swallowing, or the closure of the glottis (so that blood may run quietly into the stomach, or even into the lungs) ; yet, with all this, they may breathe steadily, and shew that the power of the med: oblong: to combine in action all the nerves of the respiratory muscles is perfect.

Mesocephalon or Pons Varolii.

This term denotes that this portion of the encephalon is the bond of union to the rest, the cerebrum above, the medulla oblongata below, and the cerebellum behind. The Brain anatomically is usually divided into these 4 parts. The Meso-cephalon, is called also, pons, pons Varolii, or tuber annulare; isthmus encephali, or nodus encephali.

The Pons is composed principally of transverse fibres connecting the 2 hemispheres of the cerebellum, and forming its principal commissure. But it includes, interlacing with these, numerous longitudinal fibres which connect the med: oblong: with the cerebrum, and transverse fibres which connect it with the cerebellum. Among the longitudinal fibres of the pons, the inferior and some of the superior connect the anterior pyramidal, the olivary, and the round tracts of the med: oblong: with the cerebrum; while others of the superior fibres connect with it the posterior and internal columns of the medulla. By the transverse fibres of the pons, a part of the anterior and lateral tracts, and, apparently, the whole of the restiform tracts of the med: oblong: are connected with the cerebellum; so that the pons may be regarded as containing the several means, 1st. by which the cerebrum is connected with all the tracts of the med: oblong:, except the restiform and lateral; 2nd. by which

the cerebellum is connected with these 2 tracts; 3rd. those by which its 2 hemispheres are united; and lastly (if we may reckon the processus ariformes or ponticulus as part of the pons), the fibres by which the anterior pyramidal and the restiform tracts of the medulla oblong: are connected with each other. And among the fasciculi of nerve fibres by which these several parts are connected, the pons also contains abundant grey or vesicular substance, which appears irregularly placed among the fibres, and fills up all the interstices.

On the superior surface of the Pons are the quadrigeminal bodies (nates and testes) and beneath these the olivary Columns. A slight longitudinal groove separates these bodies into a right & left pair, and a transverse groove, divides them into an anterior & posterior pair. They are ganglyform bodies, grayish white colour, containing fibrous and vesicular matter. The anterior (nates) are somewhat elliptical in shape, and are larger in man. The posterior (testes) are hemispherical, & somewhat lighter in colour. These bodies are more developed in the lower animals than in man. In mammalia only do they exist as four. In birds, reptiles & fishes they are only 2 in number, & are called optic lobes from their connexion with the optic nerves. They are hollow in these classes, but in mammalia are solid.

Between each testis and the corresponding hemisphere of the cerebellum, a band of fibrous matter

matter extends — processus cerebelli ad testem. Each hand may be traced into the crus cerebelli of same side. The valve of Vieussens occupies the interval between these processes. The crura cerebelli seem to emerge from the posterior angles of the Pons.

Functions of the Pons. As a conductor of impressions, one may consider the Pons, as its anatomy would suggest, to contain the continuation of the conducting portion of the med: oblong: to the cerebrum and cerebellum. Longet says that acute pain is produced by touching its posterior part, but, by irritation of its interior, no pain, but convulsions of the face, limbs, and other parts. But the results of experiments respecting its conducting power are confused by those of the injuries of the crura cerebri and crura cerebelli, which will be hereafter referred to.

As a nervous centre, it appears probable that the Pons may be regarded as the first, or lowest portion of the encephalon, in which, when the rest of the brain is removed, the mind may have sensation of impressions or exercise the will. When all the encephalon above the med: oblong: is removed from a warm-blooded animal, it appears absolutely insensible, & deprived of all voluntary power; it only breathes, & has other, generally useless, reflex movements of the trunk and limbs. But experiments of Flourens and Longet shew that when the pons is left,

with the medulla oblong:, indications of sensibility may be elicited, and the movements ~~still~~ that follow them are characteristic of purpose and will.

It must, therefore, be assumed either that the pons is an organ through which the mind may receive and transmit impressions, or that it is a nervous centre for higher and more useful reflex acts, than the medulla oblongata or any part of the spinal cord.

Structure & Physiology Cerebellum and Structure of Cerebrum.

G. D. Gibb M.D.

30th Decem 1851

To illustrate

Cerebellum, section of to show arbor vitae

Fig 71 of Todd page 271

" 55 of Todd -

Cerebrum in Med & Phy Dictionary.

Structure of the Cerebellum.

The more we ascend towards the highest organs of the cerebro-spinal system, the more difficult it becomes to trace any structure beyond that of external form and connection, and much more so to connect even the manifest structure with any of the functions of the part. With regard to the Cerebellum, there appears at present so complete a want of connection between its Anatomy and Physiology, that I shall confine myself to a general outline of its structure, sufficient for that part of my lecture treating more particularly upon this portion of the encephalon.

The Cerebellum is situated above and behind the medulla oblongata in a distinct compartment of the cranium, which has for its roof the tentorium cerebelli. It bears to the Cerebrum in point of weight about the proportion of 1 to 8, and to the entire encephalon, 1 to 10.

The cerebellum consists of a central and of two lateral portions. The former, also called the median lobe, is the primary part; it is the only part of the organ which exists in fishes and reptiles; the lateral portions or hemispheres are additions to this, and denote an advance in development. It is in

birds that these are first found; they are most highly developed in mammals and attain their maximum in man.

Like the cerebrum, the cerebellum is composed of grey and white substance, the former occupying the surface, and the latter the interior, and its surface is formed of parallel laminae separated by sulci or grooves, and bound there by deeper sulci.

A vertical section of either hemisphere shows the appearance denominated arbor vitae cerebelli the white substance in the centre of such a section resembles the trunk of a tree from which branches are given off, and from the branches, branchlets and leaves, the 2 latter being coated by a moderately thick and uniform layer of grey substance.

These terminations in branchlets and leaves are called lobules, and each lobule is circumscribed and separated from its neighbours by a fissure.

Now the fissures are of 2 kinds or classes, the primary and secondary. The primary penetrate to the principal central column, and isolate the lobules; the secondary separate the lamellae of which each lobule is composed. The pia mater enters into all these fissures as in the convolutions of the brain or cerebrum. (show section of cerebellum)

The structure of the median lobe is the same as the hemispheres. A stem of fibrous matter, continuous with the processus cerebelli ad testes,

constitutes the central column, and plates or lamellæ radiate from it in the same manner as in the hemispheres. Lobules are formed around these plates and the aggregate of those on the superior surface of the median lobe constitutes what is called the superior vermiform process; and that of the inferior ones, the inferior vermiform process. The entire median lobe becomes a medium of connexion or a commissure between the hemispheres.

Within the central stem of each hemisphere of the cerebellum, the fibrous matter is partially interrupted by a peculiar arrangement of the vesicular substance, called by Vicq d'Azyr Corpus dentatum. (Fig 71 Todd. A.) This is only found in the inner half of the stem, at about a quarter of an inch from the origin of the crus. It may be seen on a vertical section thro the cerebellar hemisphere, leaving 2/3rds of its substance to the outside of the section.

The surface of the section presents at the situation just described a remarkable layer or capsule of gray matter, surrounding in great part an oval space; the gray layer has an undulating disposition, and is convex towards the surface but open towards the crus. The precise object of this remarkable structure is not known; but the microscopic investigation of it shews that

in it there is a mingling of the elements of the vesicular and fibrous substances.

The association or connection of the cerebellum with the rest of the encephalon is by means of 3 pairs of rounded cords or pedunceles, superior, middle and inferior, which combined form the 2 crura cerebelli. The hemispheres of the cerebellum appear to be formed on the prolongations of fibres in the crura cerebelli; these fibres are derived from 3 sources, namely:

1st the restiform tracts of the medulla oblongata, which form the inferior crura or pedunceles; the crura ad medulla oblongatam; they, the pedunceles descend & the posterior part of the med: oblong:, and form the inferior portion of the lateral boundaries of the 4th Ventricle.

2nd. interchanging or commissural fibres, which together with fibres going outwards from the lateral tracts of the med: oblong:, form the middle crura or pedunceles. The middle pedunceles, or crura cerebelli ad pontem, are the largest of the three, and may be seen issuing from the cerebellum thro the anterior extremity of the sulcus horizontalis and are lost in the pons Varolii.

3rd. by fibres interchanging between the cerebellum and cerebrum, which form the superior crura or pedunceles, or processus a cerebello ad testem. The superior pedunceles, or proceeding from the cerebellum

forwards and upwards, are lost in the testes.

To sum up in a few words, the prolongation of the crus cerebelli, in which these 3 fasciculi of fibres, or pedunculs are combined, contains, imbedded in it, a mass of grey matter, the corpus dentatum, already described, ~~ends~~ sends off lamellae, which separate and are arranged like the nervules of a leaf, and are overlaid with layers of grey matter, folded and closely adjusted over the ends of the nervules. The pons as stated in a previous lecture, forms the inferior and principal commissure connecting the 2 hemispheres of the cerebellum; but they are also united above, by a continuity of both grey and white substance, arranged in the same general plan as in themselves, in the vermiform processes.

Respecting the intimate structure of the cerebellum, little is known of a very exact nature. The white stems and plates are fibrous, and consist of multitudes of nerve tubes of all sizes, which follow the general direction of each stem or plate.

The vesicular matter which covers the plates contains the ordinary elements, of which however the caudate vesicles constitute a principal portion, (Fig 55 of Todd). These are so disposed that their processes pass off chiefly towards the circumference, their obtuse extremities being directed towards the laminae.

Physiology of the Cerebellum.

The physiology of the cerebellum may be considered in its relation to sensation, voluntary motion, & the instincts or higher faculties of the mind.

It is itself insensible to irritation, and may be all cut away without eliciting signs of pain. Yet, if any of its crura be touched, pain is indicated; and, if the restiform tracts of the med: oblong: be irritated, the most acute suffering is induced. Its removal or disorganization by disease is, also, generally unaccompanied with loss or disorder of sensibility; animals from whom it is removed can smell, see, hear and feel pain to all appearance, as perfectly as before. So that, although the restiform tracts of the med: oblong: which are themselves so sensitive, and the continuations of the especially sensitive columns of the spinal cord, enter the cerebellum, it cannot be regarded as a principal organ of sensibility.

In reference to motion, the experiments of Longet and most others agree that no irritation of the cerebellum produces movements of any kind; and these are probably correct though Valentin says that irritation of it

(as of some other parts of the encephalon) produces movements of the stomach, intestines, urinary bladder, and vasa deferentia. More uniform and remarkable results are produced by removing parts of the cerebellum. Flourens, (whose experiments have been abundantly confirmed by those of Bouillaud Longet, and others,) extirpated the cerebellum in birds by successive layers. Feebleness and want of harmony of the movements were the consequence of removing the superficial layers. When he reached the middle layers, the animals became restless without being convulsed; their movements were violent and irregular, but their sight and hearing were perfect. By the time that the last portion of the organ was cut away, the animals had entirely lost the powers of springing, flying, walking, standing, and preserving their equilibrium. When an animal in this state was laid upon the back, it could not recover its former posture; but it fluttered its wings, and did not lie in a state of stupor; it saw the blow which threatened it, and endeavoured to avoid it. Volition, sensation, and memory, therefore, were not lost, but merely the faculty of combining the actions of the muscles; and the endeavours of the animal to maintain its balance were like those of a drunken man.

The experiments afforded the same results when repeated on all classes of animals, and

from them and the others before referred to Flourens inferred that the cerebellum belongs neither to the sensitive nor to the intellectual apparatus; and that it is not the cause of voluntary movements, although it belongs to the motor apparatus; but is the organ for the co-ordination of the voluntary movements, or for the excitement of the combined action of muscles.

Some cases of disease of the cerebellum confirm this view; but the majority afford only negative evidence. On the whole also, it is confirmed by comparative anatomy.

The tables of M. Serres shew that although, with some exceptions, in the ascending scale of the Vertebrata, the cerebellum undergoes a general increase of size, and acquires an increasing preponderance over the spinal cord, so that we cannot say that its development is unconditionally proportionate to the faculty of combining muscular movements, yet, in each of the 4 classes of Vertebrata, the species whose natural movements require most frequent and exact combinations of muscular actions are those whose cerebella are most developed in proportion to the Spinal Cord.

On the strength of all these evidences, the view of M. Flourens has been generally

adopted. But M. Foville holds that the cerebellum is the organ for the perception of muscular sensibility; i.e. of the sensations derived from muscles, through which the mind acquires that knowledge of their actual state and position which is essential to the exercise of the will upon them. It must be admitted that all the facts just referred to are as well explained on this hypothesis as on that of the cerebellum being the organ for combining movements, and this hypothesis is, perhaps, more consistent than M. Flourens' with the very close connection between the cerebellum & the posterior columns of the cord.

Gall was led to believe the cerebellum is the organ of physical love, or, as Spurzheim called it, amativeness; and this view is generally received by phrenologists. The facts favouring it are, first, several cases in which atrophy of the testes and loss of sexual passion has been the consequence of blows over the cerebellum or wounds of its substance; secondly, cases in which disease of the cerebellum has been attended with almost constant erection of the penis, and frequent seminal emissions; and thirdly, that it has seemed possible to estimate the degree of sexual passion in different persons by an external examination of the region of the cerebellum. With regard to the first class

of facts, they are open to the objection that the loss of the sexual passion may have been the consequence of the loss of the testes, and that the latter loss may have been due to some connection in the process of nutrition, between the cerebellum and testes, similar to that which exists between the testes and the hair and other parts, whose growth indicates the attainment of puberty, and for a time the maintainance of virility.

These facts have little bearing on the question unless it is shewn that the loss of sexual passion followed the injury of the cerebellum before the testes began to diminish. The cases of disease of the cerebellum do not prove more; for the same affections of the genital organs are more generally observed in diseases, and in experimental irritations, of the medulla oblongata and upper part of the spinal cord.

The facts drawn from Craniological examination will receive the credit given to the system of which they are the principal evidence. But in opposition to them it must be stated, that there has been a case of complete disorganization or absence of the cerebellum without loss of sexual passion; that the cocks from whom M. Flourens removed the cerebellum, showed sexual desire, though they were incapable of gratifying it; and

that among animals there is no proportion observable between the size of the cerebellum and the development of the sexual passion. On the contrary, many instances may be mentioned in which a larger sexual appetite coexists with a smaller cerebellum; as e.g. that rays and eels, which are among the fish that copulate, have no laminae on their almost rudimental cerebella; and that cod-fish, that do not copulate, but deposit their generative fluids in the water, have comparatively well developed cerebella. Among the Amphibia the sexual passion is exceedingly strong in frogs and toads; yet the cerebellum is only a narrow bar of nervous substance. Among birds there is no enlargement of the cerebellum in the males that are polygamous: the domestic cock's cerebellum is not larger than the hen's, though his sexual passion must be estimated as many times greater than hers. Among Mammalia the same rule holds; and in this class the experiments of M. Lassaigne have plainly shewn that the abolition of the sexual passion by removal of the testes in early life is not followed by any diminution of the cerebellum; for in mares and stallions the average absolute weight of the cerebellum is 61 grains, and in

feldings 70 grains; and its proportionate weight, compared with that of the cerebrum, is, on an average, as 1: 6·59 in mares; as 1: 5·97 in fillings, and only as 1: 7·07 in stallions.

On the whole, therefore, it appears advisable to wait for more evidence before concluding that there is any peculiar and direct connection between the cerebellum and the sexual instinct or passion sexual. From all that has been observed, no other office is manifest in it than that of regulating and combining muscular movements, or of enabling them to be regulated and combined by so informing the mind of the state and position of the muscles that the will may be definitely and aptly directed to them.

The influence of each half of the cerebellum is directed to muscles on the opposite side of the body, and it would appear, that for the right ordering of movements, the actions of its 2 halves must be always mutually balanced and adjusted. For, if one of its crura, or, if the pons on either side of the middle line, be divided, so as to cut off from the med: oblong: and spinal cord the influence of one of the hemispheres of the cerebellum, strangely disordered movements ensue. The animals fall down on the side opposite

to that or which the crus cerebelli has been divided, and then roll over continuously & repeatedly; the rotation being always round the long axis of their bodies, and from the side on which the injury has been inflicted. The rotations sometimes take place with much rapidity; as often, according to Magendie as 60 times in a minute, and may last for several days. Similar movements have been observed in men; as by M. Serres, in a man in whom there was an apoplectic effusion in the right crus cerebelli; and by M. Belhomme in a woman, in whom an exostosis pressed on the left crus. They may perhaps, be explained by assuming that the division or injury of the crus cerebelli produces paralysis, or imperfect and disorderly movements, of the opposite side of the body; the animal falls, and then, struggling with the disordered side on the ground, and striving to rise with the other, pushes itself over; and so, again and again, with the same act rotates itself. Such movements cease when the other crus cerebelli is divided; but probably only because the paralysis of the body is thus made almost complete.

Structure of the Cerebrum

In giving the structure of the Cerebrum, only so much shall be considered as will be essential towards its physiological investigation. For the minute anatomy of the Brain generally with all its particularities I must refer you to the Lectures on Anatomy, and to such anatomical works as treat especially on the subject.

The cerebrum is placed in connection with the pons and med: oblong: by its 2 crura or pedunculi. It is connected with the cerebellum by the processes called superior Crura of the cerebellum or processus a cerebello ad testes, and by a layer of grey matter, called the nature of Vieussens, which lies between these processes and extends from the inferior medullary process of the cerebellum to the carpora quadrigemina of the cerebrum. These parts which thus connect the cerebrum with the other principal divisions of the cerebro-spinal nervous centre form parts of the walls of a cavity (the 4th ventricle) and a canal, (the iter a tertio ad quartum ventriculum), which are the continuation of the canal that in the foetus extended through the whole length of the spinal cord & brain. They may therefore be regarded as the continuation

of the cerebro-spinal axis or column; on which, as a developement from the simple type, the cerebellum is placed; and, on the further continuation of which, structures both larger and more numerous are raised, to form the cerebrum.

The Crura cerebri are principally formed of nerve fibres, of which the inferior are continuous with those of the anterior pyramidal and olivary tracts, and the superior with the round and posterior pyramidal tracts of the medulla oblongata. They may therefore be regarded as, principally, conducting organs; but each of them manifests also the character of a nervous centre, in that it contains a mass of vesicular substance, the locus niger, whose nerve corpuscles abound in pigment granules, and afford some of the best examples of the caudate structure. The office of the Crura cerebri as conductors will appear in speaking of the relation of the cerebrum to voluntary motion, and the peculiar effects of their division: as centres, they are probably connected with the functions of the 3rd nerve, which arises from their inner margins, and through which are directed the chief of the numerous and complicated movements of the eyeball and iris.

On their upper part the Crura cerebri bear 3 pairs of small ganglia, or masses of mingled grey and white nerve substance; namely, the corpora geniculata externa and interna, and the corpora

quadrijemina, or nates and testes. Beneath or through the corpora quadrijemina pass the continuations of the raund and posterior pyramidal tracts of the medulla; decussating as they proceed onwards: and nearer to the upper surface of the same ganglia pass the fibres of the superior crura of the the cerebellum, mingling with the fibres that form the chief part of the origin of the optic nerves, with the functions of which nerves these ganglia appear intimately connected.

In its further course, each crus cerebri, enlarged by the addition of many fibres, forms as it proceeds, a kind of fibrous cone, with its truncated apex in the pons. On it are placed in succession 2 other ganglia, the optic thalamus and corpus striatum, in which its fibres and those that are continually added to them, traverse ravined-shaped masses and layers of grey substance, and from the anterior part of which, diverging in all directions and tending backwards, they pass into the substance of the corresponding cerebral hemisphere.

These several organs on each side of the cerebrum are connected by commissures, formed principally of nerve fibres; namely, the corpora quadrijemina connected by part of the fibres of the raund tract which form the fillet of Reil, and meet in the middle line; the optic thalami connected by the anterior & posterior commissures formed of fibres, and the middle or

For further descriptions of structure of the brain, refer to Todd and Mayo; and also Quain Fouille and Lorget. The 2 former are the most convenient -

soft commissure of grey substance; part of the corpora striata and the cerebral hemispheres, connected, by the anterior commissure and corpus callosum.

The lateral parts of each of the hemispheres are also connected by longitudinal and oblique fibres passing beneath the convolutions from one part to another; and, in the median part of the fornix, connecting the middle cerebral lobe with the optic thalamus.

The cerebral convolutions appear to be formed of nearly parallel plates of fibres, the ends of which are turned outwards towards the surface of the brain, and are overlaid and mingled with successive layers of grey nerve substance. Some have supposed that the ends of the fibres are connected in loops, of which loops, parts are continued from the diverging fibres of the cone, and others from the fibres of the corpus callosum; but this is uncertain. The external grey matter is so arranged in layers that a vertical section of a convolution generally presents the appearance of 3 layers of grey, with 2 intervening layers of white substance, a grey layer being most external. In these grey layers the outer is formed principally of granular matter and nuclei, like those of nerve corpuscles; in the deeper layer are more perfectly formed cells.

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Functions of the Cerebrum.

G. Gibbes M.D.

1st January 1852

To illustrate

Brain of fishes, Birds, &c.

Coloured diagrams of to show optic lobes.

Wigans Duality of the Mind.

Functions of the Cerebrum.

Effects of division of the Crura Cerebri.

The Crura Cerebri appear as the principal conductors of impressions to and from the cerebrum, and division of one of them produces singular effects on the movements. When one is cut across the animal moves round and round, rotating round a vertical axis, from the injured towards the sound side, as if from a partial paralysis of the side opposite to the injury. The effect may be supposed due to the interruption of the voluntary impulses from the cerebrum; for even though the cerebellum may have the office of combining the muscles whose co-operation is necessary for each action, yet it is probable that the deliberate effort of the will must proceed from the cerebrum. The movements of an animal are more disordered when the cerebellum is removed and the cerebrum is left, than when both cerebrum and cerebellum are removed; as if, in the latter case, the voluntary power were evoked but not disordered, but in the former, acted with full strength but with disorder.

Functions of the Corpora Quadrigemina or Optic Lobes.

The corpora quadrigemina (from which, as in function, the corpora geniculata are not distinguished), are the homologues of the optic lobes in the birds, Am-

=phibia,

and fishes, and may be regarded as the principal nervous centres for the sense of sight. The experiments of Flourens, Longet and Hertwig, show that removal of the corpora quadrigemina wholly destroys the power of seeing; and this cases in which they are disorganized are usually accompanied with blindness. Atrophy of them is also often a consequence of atrophy of the eyes.

Destruction of one of the corpora quadrigemina (or of one optic lobe in birds) produces blindness of the opposite eye. The loss of sight thus produced is not only because the corpora quadrigemina contain continuations of the optic tracts, or roots of the optic nerves, but because they are the organs in which the mind perceives the sensations of light. As Longets experiments show, when the cerebral hemispheres of a pigeon are removed, and its optic thalami and optic lobes are left, it not only exhibits the reflex movements of the contraction of the iris, and the closure of the eyelids when a candle is held to the eye, but when the candle is removed round before the eye, it moves its head after it, manifestly because it sees and watches it. It appears indeed not to see many things, and runs against obstacles; but this is because though it may see them it cannot recognise them, having lost all memory of objects through the loss of its cerebrum.

The loss of sight is the only apparent injury of sensibility sustained by the removal of the corpora quadrigemina. The removal of one of them affects the movements of the body, so that animals rotate, as after division of the crus cerebri, only more slowly; but this is probably due to giddiness and loss of sight. The most evident and direct influence is that produced on the iris. It contracts when the corpora quadrigemina are irritated: it is always dilated when they are removed; so that they may, perhaps, be regarded as the nervous centres governing its movements, and adapting them to the impressions derived from the the retina thro the optic nerves & tracts.

There is no evidence that the corpora quadrigemina are, in any sense, organs of the intellectual faculties, or of the affections. Yet it may be questioned if their connection with vision be their only function, seeing their large size in fish whose iris is not moveable, and that generally neither their absolute nor their proportionate size in different animals bears any simple relation to the acuteness or extent of their several powers of vision.

Functions of the Optic Thalami. The optic thalami probably participate in a small degree in the visual function of the corpora quadrigemina, for part of the fibres of the optic tract may be

traced to their surfaces. But the results of experiments prove nothing on this point. They only shew disturbances of the power of movement. Irritation of the optic thalami produces no convulsions, & only little pain (according to Longet & Flourens); destruction of one has effects very similar to those of division of one crus cerebri, namely, a rotation in which the animal, remaining standing, turns continually round. Schiff, by whom a series of experiments on these various rotations has been made, has shewn that no such effect follows the removal of any other part of the brain; and Longet points out, as a strong contrast, that after removing all the cerebral hemispheres and the corpora striata, the animal can still stand and walk, but that on removing one of the thalami optici it falls down paralysed on the opposite side, or commences the rotatory movement. The evidence of apoplexy and other diseases is similar; all such cases manifest a loss of power of part or the whole of the opposite side of the body.

Function of the corpora striata. Concerning the function of the corpora striata, experiments & the effects of diseases, permit none but negative conclusions — such as that they are not the Central organs for the sense of smell, nor peculiarly concerned in sensation or movement. The recent experiments of Schiff confirming and, in many

respects, correcting those of Magendie and others, shows that when they are removed in rabbits sensation is unimpaired, and the power of movement complete; so that although at first the creature remains at rest, it will after irritation, or spontaneously, in about half an hour begin to move, at first slowly, and then with increasing speed and larger leaps, till it strikes against some obstacle, when it falls, and again for a time remains torpid.

Various explanations are offered of these and other strange movements which ensue when the several parts just considered are mutilated, such as that particular masses or tracts in the brain determine the impulses to move in this or that direction, and that, by destroying any part, the balance in which its impulse holds that of the corresponding part of the opposite side is lost. But no such explanations guide to the true physiology of these parts.

Taking together all the parts yet considered, i.e. all the parts of the cerebro-spinal nervous system except the cerebral hemispheres, they appear to include the apparatus; 1st. for the direction and government of all the impelled and involuntary movements of the parts which they supply. 2nd. for the perception of sensations, and 3rd for the direction of such instinctive and

habitual movements as do not require the exercise of judgment, deliberation, memory, or any other intellectual act. The medulla oblongata and spinal cord have their office in none but involuntary and unconscious movements; but above the medulla oblongata, the pons, and other organs appear capable of such conditions as the mind may perceive, and of being, by the will excited to the production of voluntary and orderly movements. But these parts cannot be regarded as organs of the higher faculties of the mind: with them alone, an animal appears to possess neither memory of former sensations, nor judgment to determine and control its actions. Mere sensations, and will, acting according to instinctive impulse and instinctive knowledge or habit, constitute the whole mind of the animal deprived of its cerebral hemispheres.

But seeing what manifestations of mind exist in animals, after the removal of the cerebral hemispheres, it is reasonable to suppose that these lower organs, the cerebral or sensory ganglia naturally discharge the functions of which they then appear capable, and that the cerebral hemispheres are engaged only in the higher mental acts. This appears the more probable when it is considered that all the cerebral nerves are in direct connection with these ganglia; and are only through

the medium of the highest of them, (including herein the olfactory ganglia as part of the brain) connected with the cerebral hemispheres; so that whatever acts are performed through these nerves, independantly of the higher faculties of the mind, may be fairly ascribed to the power of these nervous ganglia.

Carpenter regards "the series of ganglionic centres just enumerated as constituting the real sensorium; each ganglion having the power of communicating to the mind the impressions derived from the organ with which it is connected, and of exciting automatic muscular movements in response to these sensations." He also regards "the ganglionic tract as the immediate ~~centre~~ centre of those movements which directly result from the excitement of the emotions."

Of the Functions of the Cerebral Hemispheres.

If it be probable that the function of the parts already considered are correctly indicated in what has just been said, it will be in the same degree probable that the functions of the Cerebral Hemispheres, thus determined by "way of exclusion," are those of the organs by which the mind, 1st perceives those clear and more impressive sensations which it can retain, and judge according to. 2ndly, performs those acts of will each of which requires a deliberate, however quick, determination; 3rd ly, retains

impressions of sensible things, and reproduces them in subjective sensations and ideas; 4th ly, manifests itself in its higher and peculiarly human emotions and feelings, and in its faculties of judgment, understanding, memory, reflection, induction, and imagination, and others of the like class. The cerebral hemispheres appear thus to be the organs in and through which the mind acts, in all those its operations which have immediate relation to external & sensible things; and this view may be held without fear, while it is held also, that the mind has other and higher parts or faculties, by which it has or may attain to knowledge of things above the senses; namely, the Conscience and the pure reason, which may be instructed otherwise than thro the senses, and exercised independently of the brain.

The evidence that the cerebral hemispheres are, in the sense and degree just stated, the organs of the mind, are chiefly these: —

1. That any severe injury of them, such as a general concussion, or sudden pressure by apoplexy, may instantly deprive a man of all power of manifesting externally any mental faculty.

2. That in the same general proportion as the higher sensuous mental faculties are developed in the vertebrate animals, and in man at different ages, the mass are the size of the cerebral

hemispheres developed in comparison with the rest of the cerebro spinal system.

3rd That no other part of the nervous system bears corresponding proportion to the development of the mental faculties. 4. That congenital & other marked defects of the cerebral Hemispheres are, in general, accompanied with correspon=ding deficiency in the range or power of the intellectual faculties and the higher instincts.

To explain such facts, no hypothesis is so sufficient as that which supposes an immaterial principle, not necessarily dependant for its exis=tence on the brain, but incapable of external man ifestation, or of knowledge of external things, except through the medium of the brain, and the nervous organs connected therewith. Such a principle would remain itself unchanged, in the case of injury or disease of the brain; but its ex=ternal manifestations, and all its acts performed in connection with the brain, would be hindered or distorted; as, for example, the work of any artist might be stopped or spoiled through de=ficiency or badness of his implements of art. And in the operations of such a principle, it might well be supposed that the power with which its several faculties are manifested would bear a direct proportion to the size of the organs through which they are manifested; for whether

we suppose or not that the principle itself may, in different individuals, have different degrees of power, yet its power of manifestation or perception through the cerebral hemispheres, may vary as those organs do.

Respecting the mode in which the mental principle operates in its connection with the brain there is no evidence whatever. But it appears that, for all but its highest intellectual acts, one of the cerebral hemispheres is sufficient. For numerous cases are recorded in which no mental defect was observed, although one cerebral hemisphere was so disorganized or atrophied, that it could not be supposed capable of discharging its functions. The remaining hemisphere was in these cases adequate to the functions generally discharged by both; but the mind does not seem in any of these cases to have been tested in very high intellectual exercises, so that it is not certain that one hemisphere will suffice for these. In general, the mind combines, as one sensation, the impressions which it receives derives from one object through both hemispheres, and the ideas to which the 2 such impressions give rise are single; and in general, also, the mind acts alike in and through both the hemispheres:

its

actions being, if we may so speak, symmetrical as the hemispheres are. But it would appear that when one hemisphere is disordered, the same object may produce 2 sensations, and suggest simultaneously different ideas: or, at the same time, two trains of thought may be carried on by the one mind acting, and being acted upon, differently in the 2 hemispheres. Thus are explicable some of the incoherences of dreaming and delirium; and especially, those singular cases in which a person in delirium, puzzled by the 2 different, and seemingly simultaneous, trains of thought in which he is engaged, fancies himself 2 persons, and, as another, holds conversation with himself.

For interesting facts concerning the Duality of the mind, I would refer you to Wigans Duality of the mind — I have it.

In relation to common sensation and the effort of the will, the impressions to and from the hemispheres of the brain are carried across the middle line; so that in destruction or compression of either hemisphere, whatever effects are produced in loss of sensation or voluntary motion, are observed on the side of the body opposite to that on which the brain is injured.

In speaking hitherto of the cerebral hemispheres as the organs of the mind, they have been regarded as if they were single organs of which all parts are equally appropriate for the exercise of each of the mental faculties. But it is a more probable theory that each faculty has a special portion of the brain appropriated to it as its proper organ. For this theory, the principal evidences among those collected by Drs Gall and Spurzheim are as follows:

1. that it is in accordance with the physiology of the other compound organs or systems in the body, in which each part has its special function; as, for example, of the digestive system, in which the stomach, liver, and other organs perform each their separate share in the general process of digestion of the food.

2. That in different individuals, the several mental functions are manifested in very different degrees. Even in early childhood, before education can be imagined to have exercised any influence on the mind, children exhibit various dispositions, each presents some predominant propensity, or evinces a singular aptness in some study or pursuit; and it is matter of daily observation that every one has his peculiar talent or propensity. But it is difficult to imagine how this could be the case, if the

manifestation of each faculty depended on the whole of the brain; different conditions of the whole mass might affect the mind generally, depressing or exalting all its functions in an equal degree, but could not permit one faculty to be strongly and another weakly manifested.

3. The plurality of organs in the brain is supported by the phenomena of some forms of mental derangement. It is not usual for all the mental faculties in an insane person to be equally disordered; it often happens that the strength of some is increased, while that of others is diminished; and in many cases one function only of the mind is deranged, while all the rest are performed in a natural manner.

4. The same opinion is supported by the fact that the several mental faculties are developed to their greatest strength at different periods of life, some being exercised with great energy in childhood, others only in adult age; and that, as their energy decreases in old age, there is not a gradual and equal diminution of power in all of them at once, but on the contrary, a diminution in one or more, while others retain their full strength, or even increase in power.

5. The plurality of cerebral organs appears to the

indicated by the phenomena of dreams, in which only a part of the mental faculties are at rest or asleep, while the others are awake, and, it is presumed, are exercised through the medium of the parts of the brain appropriated to them.

6. It is stated that the examination of the brains of individuals, each remarkable for some peculiar propensity or talent, has always demonstrated a corresponding development of a certain portion of the brain.

These facts have been so illustrated & adapted by phrenologists, that the theory of the plurality of organs in the cerebrum thus made probable, has been commonly regarded as peculiar to phrenology, and as so essentially connected with it, that if the system of Gall and Spurzheim be untrue, this theory cannot be maintained. But it is plain that all the system of phrenology built upon the theory may be false, and the theory itself true: for the school of Gall & Spurzheim assume, not only this theory, but also that they have determined all the primitive faculties of which the mind consists, i.e. all the faculties to which special organs must be assigned, and the places of all those organs in the cerebral hemispheres and the cerebellum. Possibly this may be a system of error, founded on a true theory: the cerebrum may have many organs,

and the mind as many faculties; but what are the faculties that require separate organs, and where those organs are, may be subjects of which only the first or most general knowledge is yet attained. At any rate, the phrenological physiology of the brain, cannot be here considered without interference of the present course of lectures.

Of the physiology of the other parts of the brain, little or nothing can be said.

Of the offices of the Corpus callosum, or great transverse commissure[3] and oblique[2], of the brain, nothing positive is known. But instances in which it was absent, or very deficient either without any evident mental defect, or with only such as might be ascribed to coincident affections of other parts, make it probable that the office which is commonly assigned to it, of enabling the 2 sides of the brain to act in concord, is exercised only in the highest acts of which the mind, acting on the brain is capable. And this view is confirmed by the very late period of its development, and by its absence in all but the placental mammalia.

To the fornix and other commissures no special function can be assigned; but it is a reasonable

hypothesis that they connect the actions of the parts between which they are severally placed.

As little is known of the functions of the pineal and pituitary glands. Indeed, Oesterlen raises the question whether either their structure or functions are those of nervous organs, and classes them among glands without ducts.

Physiology of the Cerebral & Spinal Nerves.

The cerebral nerves are 12 pairs, and the spinal nerves 31 pairs, symmetrically arranged on each side of what, reduced to its simplest form, may be regarded as a column or axis of nervous matter, extending from the olfactory bulbs on the ethmoid bone, to the filum terminale of the spinal cord in the lumbar and sacral portion of the vertebral column. The spinal nerves all present certain characters in common, such as their double roots; the isolation of the fibres of sensation in the posterior roots, and of those of motion in the anterior roots; the formation of the ganglia on the posterior root; and the subsequent mingling of the fibres in trunks and branches of mixed functions. Similar characters probably belong essentially to the cerebral nerves; but even when one includes the nerves of special sense, it is not possible

discern a conformity of arrangement in any besides the 5th or trifacial, which, from its many analogies to the spinal nerves, Sir Charles Bell designated as the spinal nerve of the head.

According to their several functions, the cerebral or cranial nerves may be thus arranged: —

Nerves of special sense.	Olfactory, Optic, Auditory, part of the glosso-pharyngeal, and the lingual branch of the 5th.
Nerves of common sensation.	The greater portion of the 5th, and part of the glosso-pharyngeal.
Nerves of motion.	3rd, 4th, lesser division of 5th, 6th, facial, and hypoglossal
Mixed nerves.	Pneumogastric, and spinal accessory.

Physiology of 3rd, 4th, & 6th,
nerves. The 5th or Trigeminal.
The Facial. And the Glosso Pharyngeal.

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2nd January 1852

To illustrate

Plates of 3rd, 4th & 6th Nerves
do of 5th or Tripeminal
do of facial
do of Glassopharyngeal
for these see Quains Nerves plates 8.13.14 & 15.
plates 6 & 11 of Sezars
Arnolds plate in Mortons Head & Neck.

3rd nerve arises from the inner side of the crus cerebri, close to the Pons Varolii, and passes forward between the posterior cerebral and superior cerebellar artery.

Physiology of the Cerebral & Spinal Nerves.

The physiology of the Sensual nerves of the special Senses will be considered with the organs of those Senses.

Physiology of the 3rd, 4th, and 6th Cerebral or Cranial Nerves.

The physiology of these nerves may be combined, from their intimate connection with each other in the actions of the muscles of the eye ball, which they supply. They are probably all formed exclusively of motor fibres: some pain is indicated when the trunk of the 3rd nerve is irritated near its origin, but this may be from some filaments of the 5th nerve running backwards to the brain in the trunk of the 3rd, or because adjacent sensitive parts are involved in the irritation.

Anatomy. The third nerve, or motor oculi, supplies the elevator palpebrae superioris muscle, and of the muscles of the eyeball, all but the obliquus superior or trochlearis, to which the 4th nerve is appropriated, and the rectus externus which receives the 6th nerve. Through the medium of the ophthalmic or lenticular ganglion, of which it forms what is called the short root, it also supplies the motor filaments to the iris.

When the 3rd nerve is irritated within the skull, all these muscles to which it is distributed are convulsed. When it is paralyzed or divided, these

following effects ensue: first, the upper eyelid can be no longer raised by the levator palpebræ, but drops, and remains gently closed over the eye, under the unbalanced influence of the orbicularis palpebrarum, which is supplied by the facial nerve: secondly, the eye is turned outwards by the unbalanced action of the rectus externus, to which the 6th nerve is appropriated; and hence, from the irregularity of the axes of the eyes, double sight is often experienced when a single object is within view of both the eyes: thirdly, the eye cannot be moved either upwards, downwards, or inwards: fourthly, the pupil is dilated.

The relation of the 3rd nerve to the iris is of peculiar interest. In ordinary circumstances the contraction of the iris is a reflex action, which may be explained as produced by the stimulus of light on the retina being conveyed by the optic nerve to the brain (probably to the corpora quadrigemina) and thence reflected through the 3rd nerve to the iris. Hence the iris ceases to act when either the optic or the 3rd nerve is divided or destroyed, or when the corpora quadrigemina are destroyed or much compressed. But when the optic nerve is divided, the contraction of the iris may be excited by irritating that portion of the nerve which is connected with the brain; and when the 3rd nerve is divided, the irritation of its distal portion will still excite contraction of the iris in which its fibres are distributed.

4th nerve. (Smallest). arises from the nature of Wiessens, close to the testes, and winds around the crus cerebri.

6th nerve. arises by dorsal ~~constricted~~ filaments from the upper constricted part of the corpus pyramidale close to the pons Varolii.

The contraction of the iris thus shews all the character of a reflex act, and in ordinary cases requires the concurrent action of the optic nerve, corpora quadrigemina, and third nerve; and probably also, seeing the peculiarities of its perfect mode of action, the ophthalmic ganglion.

The iris acts also in association with certain other muscles supplied by the third nerve

The fourth nerve, or Nervus trochlearis or patheticus, is exclusively motor, and supplies only the trochlearis or obliquus superior muscle of the eyeball. This muscle acts spasmodically when the nerve is irritated, and is paralysed when the nerve is divided or otherwise hindered from its function. From this paralysis results a very slight, if any, deviation of the eye from its normal direction; the pupil is directed a very little upwards and outwards by the unbalanced action of the obliquus inferior, and a peculiar kind of double vision is produced in which the same object appears as 2, placed one above the other, but again appears single when the head is inclined towards the shoulder of the opposite side to that on which the superior oblique is paralysed. These phenomena are explained by the peculiar actions of the oblique muscles.

(see Kirkes page 430 -)

The sixth nerve, Nervus abducens or ocularis externus, is also, like the fourth, exclusively motor, and supplies only the rectus externus muscle.

5th. The great sensitive nerve of the head and face, and the largest cranial nerve, is analagous to the spinal nerves, in its origin by 2 roots, from the anterior and posterior columns of the spinal cord, and in the existence of a ganglion on the posterior root.

It arises from a tract of yellowish white matter situated in front of the floor of the 4th ventricle and the origin of the auditory nerve, and behind the crus cerebelli. This tract divides inferiorly into 2 fasciculi which may be traced downwards into the spinal cord, one being continuous with the fibres of the anterior column, the other with the posterior column. Proceeding from this origin the 2 roots of the nerve pass forward and issue from the brain upon the anterior part of the crus cerebelli. Here they consist of 70 to 100 filaments held together by pia mater.

The rectus externus is, therefore, convulsed, and the eye is turned outwards, when the 6th nerve is irritated; and the muscle paralysed when the nerve is disorganized, compressed, or divided. In all such cases of paralysis the eye squints inwards and cannot be moved outwards.

In its course through the cavernous sinus, the 6th nerve forms larger communications with the sympathetic nerve than any other nerve within the cavity of the skull does; and, on this ground, used to be considered as giving origin to the sympathetic. But the import of these communications with the sympathetic, and the subsequent distribution of its filaments after joining the 6th nerve are quite unknown; and there is no reason to believe that the 6th nerve is, in function, more closely connected with the sympathetic than any other cerebral nerve is.

Physiology of the 5th or Trigeminal Nerve.

The fifth, trigeminal, or trifacial nerve resembles, as already stated, the spinal nerves, in that its branches are derived through 2 roots; namely, the portio major, the filaments of which expand to become the corpuscles that form the Casserian ganglion, and the portio minor, which has no ganglion, and passes under the ganglion of the portio major to join the 3rd branch or division which issues from it. The first & second divisions

the nerve, which arise wholly from the ganglion of the portio major, are purely sensitive. The third division, which is formed in part by the portio minor, and in part from the Casserian ganglion, is, in its trunk and many of its branches both motor and sensitive.

Nat.y Through the branches of the greater or ganglionic portion of the 5th nerve, all the anterior and antero-lateral parts of the face and head, with the exception of the skin of the parotid region (which derives branches from the cervical spinal nerves) acquire common sensibility; and among these parts may be included the organs of special sense, from which common sensations are conveyed through the 5th nerve, and their peculiar sensations through their proper nerves of special sense. All the muscles, also, acquire muscular sensibility through the filaments of the ganglionic portion of the 5th nerve distributed to them with their proper motor nerves.

Through branches of the lesser or non-ganglionic portion of the 5th the muscles of mastication, namely the temporal, masseter, 2 pterygoid, anterior part of the digastric, and mylo-hyoid, derive their motor nerves. The motor function of these branches is proved by the violent contraction of all the muscles of mastication in experimental irritation of the third, or inferior maxillary, division of the nerve; by paralysis of the same muscles when it is divided or disorganised, or from any reason deprived of power; and by the retention of the

tainer of these muscles when all those supplied by the facial nerve lose their power through paralysis of that nerve. The last instance proves, that, though the buccinator muscle gives passage to, and receives some filaments from, a buccal branch of the inferior division of the 5th nerve, yet it derives its motor power from the facial, for it is paralysed together with the other muscles that are supplied by the facial, but retains its power when the other muscles of mastication are paralysed. It is probable therefore, that the buccal branch of the 5th contains no sensitive fibres; and that some of these are supplied to the buccinator muscle, as to all the other muscles some sensitive fibres are distributed to confer muscular sensibility.

The sensitive function of the branches of the greater division of the 5th nerve is proved by all the usual evidences, such as their distribution to parts that are sensitive and not capable of muscular contraction, the exceeding sensibility of some of these parts, their loss of sensation when the nerve is paralysed or divided, the pain without convulsions produced by morbid or experimental irritation of the trunk or branches of the nerve, and the analogy of this portion of the 5th to the posterior root of a spinal nerve.

But although formed of sensitive filaments exclusively, the branches of the greater or ganglionic portion of the 5th nerve exercise a manifold influence on the movements of the muscles

the head and face and other parts in which they are distributed. They do so, in the first place by providing the muscles themselves with that sensibility, without which the mind, being unconscious of their position and state, cannot voluntarily exercise them. It is probably, for conferring this sensibility on the muscles, that the branches of the 5th nerve anastomose so frequently with those of the facial & hypoglossal, and the nerves of the muscles of the eye.

Again the 5th nerve has an indirect influence on the muscular movements by conveying sensations of the state and position of the skin and other parts; which the mind perceiving, is enabled to determine appropriate acts. Thus when the 5th nerve, or its infra orbital branch is divided, the movements of the lips in feeding may cease or be imperfect; a fact which led Sir Charles Bell into one of the many few errors of his physiology of the nerves. He supposed that the motion of the upper lip, in grasping food, depended directly on the infra orbital nerve; for he found that after he had divided that nerve on both sides in an ass, it no longer seized the food with its lips, but merely pressed them against the ground, and used the tongue for the prehension of food. Mr Mayo corrected this error. He found, indeed, that after the infra orbital nerve had been divided, the animal did not seize its food with the lip, and could not

se it well during mastication, but that it could
en the lips. He therefore, justly attributed the
henomena of Sir C. Bells experiments to the loss
sensation in the lips; the animal not being
e to feel the food, and therefore, although it
d the power to seize it, not knowing how or
ere to use that power.

Lastly, the 5th nerve has an intimate con
ection with muscular movement through the
any reflex acts of muscles of which it is the
ecessary excitant. Hence when it is divided,
nd can no longer convey impressions to the ner-
ous centres to be thence reflected, the irritation
the conjunctiva produces no closure of the eye,
e mechanical irritation of the nose excites no
neezing, that of the tongue no flowing of saliva,
nd although tears and saliva may flow naturally,
eir efflux is not increased by the mechanical
r chemical or other stimuli, to the indirect or
flected influence of which it is liable in the
erfect state of this nerve.

The 5th nerve, through its ciliary branches and
the branch which forms the long root of the ciliary
r ophthalmic ganglion, exercises, also, some
influence on the movements of the iris.

Furthermore, the complete paralysis or division
of the 5th nerve, by the marked effects which it
roduces in the organs of special sense, makes
t probable that, in the normal state, the fifth

nerve exercises some indirect influence on all these organs or their functions. Thus after such complete paralysis, inflammⁿ of the whole eye (ophthalmy) commencing with opacity of the cornea. Sense of smell may be lost or impaired, and commonly part of the sense of taste is lost.

This latter loss may be due to the lingual branch of the fifth nerve being, really, a nerve of special sense.

A singular connection between the 8th nerve and the sense of sight are shewn in cases of no infrequent occurrence, in which blows or other injuries implicating the frontal nerve as it passes over the brow are followed by total blindness in the corresponding eye. The blindness appears to be the consequence of defective action of the retina; for although, in some cases, it has ensued immediately, as if from concussion of the retina, yet in some it has come on gradually like slowly progressive amaurosis, and in some with inflammatory disorganisation followed by atrophy of the whole eye. And again the 8th nerve is shewn intimately connected with the third by cases in which paralysis of the third has followed neuralgia of the 8th; and not less, by the influence of belladonna applied to the filaments of the 8th, and producing a kind of paralysis of the iris through a reflected narcotising influence on the branches of the third.

Facial arises from the upper part of the Groove between the corpus olivare and corpus restiforme close to the pons Varolii, from which point its fibres may be traced deeply into the corpus restiforme.

Physiology of the Facial Nerve.

The facial or portio dura of the 7th pair of nerves, is the motor nerve of all the muscles of the face, including the platysma, but not including any of the muscles of mastication already enumerated (page 5.); it supplies, also, through the connection of its trunk with the Vidian nerve, by the petrosal nerves, some of the muscles, most probably the levator palati and azygos uvulae, of the soft palate; by its tympanic branches it supplies the stapedius and laxator tympani, and through the otic ganglion, the tensor tympani; through the chorda tympani it supplies the lingualis and some other muscular fibres of the tongue; and by branches given off before it comes upon the face, it supplies the muscles of the external ear, the posterior part of the digastricus, and the stylo-hyoideus.

To all these muscles it is the sole motor nerve, and it is probably exclusively motor in its power; no pain is produced by irritating it near its origin, and the indications of pain which are elicited when any of its branches are irritated may be explained by the abundant anastomoses which, in all parts of its course, it forms with sensitive nerves, whose filaments being mingled with its own are the true sources of the pain.

When the facial nerve is divided, or in any other

may paralyzed, the loss of power in the muscles which it supplies, while proving the nature & extent of its functions, displays also the necessity of its perfection for the perfect exercise of all the organs of the special senses. Thus in paralysis of the facial nerve, the articulatio palpebrarum being powerless, the eye remains open through the unbalanced action of the levator palpebrae, and the conjunctiva thus exposed to the air & contact of dust is liable to repeated inflammation. These changes however, ensue much more slowly than those which follow paralysis of the fifth nerve, and never bear the same destructive character; both because the nutrition of the eye is not directly interfered with, and because the globe can still be moved upwards and inwards, so as to carry the cornea partially under the angle of the eyelid when in winking and sleeping. In paralysis of the facial nerve, also, tears are apt to flow constantly over the face, apparently because of the paralysis of the tensor tarsi muscle, and the loss of the proper direction and form of the puncta lachrymalia. By these things the sense of sight is impaired.

The sense of hearing also, is impaired in many cases of paralysis of the facial nerve; not only in such as are instances of simultaneous disease in the auditory nerves, but in such as may be explained by the loss of power in the muscles of the internal ear. The sense of smell is commonly at the same time impaired through the inability to

draw air briskly towards the upper part of the nasal cavities, in which part alone, the olfactory nerve is distributed.

Lastly, the sense of taste is impaired, or may be wholly lost, in paralysis of the facial nerve; provided the source of the paralysis be in some part of the nerve between its origin and the giving off of the chorda tympani. This result, observed in many instances of disease of the facial nerve in man, appears explicable only by the influence which, through the chorda tympani, it exercises on the movements of the lingualis and the adjacent muscular fibres of the tongue.

Together with these effects of paralysis of the facial nerve, the muscles of the face being all bemuddled, the countenance acquires on the paralysed side a characteristic, vacant look, from the absence of all expression: the angle of the mouth is lower, and the paralysed half of the mouth looks longer than that on the other side; the eye has an unmeaning stare. All these peculiarities increase, the longer the paralysis lasts; and their appearance is exaggerated when at any time the muscles of the opposite side of the face are made active in any expression, or in any of their ordinary functions. In an attempt to blow or whistle, one side of the mouth and cheek acts properly, but the other side is motionless or flaps loosely, at the impulse of the expired air; so in trying to smile, one side only of the mouth

acts; in feeding, the lip and cheek are powerless, and food lodges between the cheek & gum.

The number of movements concerned in respiration which are performed under the control of the facial nerve, and the great share which it has in the movements most expressive of the states of the mind, led Sir Charles Bell to place the facial in his class of respiratory nerves. But there are no instances in which, when unable to act under ordinary stimuli or in other functions, the facial nerve has yet been capable of action in respiratory movements; its paralysis when complete, is so in respect to every function alike. As a nerve of expression, it must not be considered independant of the 5th nerve, with which it forms so numerous anastomoses; for although it is through the facial nerve alone that all the muscles of the face are put into their naturally expressive actions, yet the power which the mind has of suppressing, controlling, and imitating or acting all these expressions, can only be exercised by voluntary and well-educated actions directed through the facial nerve with the guidance of the knowledge of the state and position of every muscle; which knowledge is required only through the 5th nerve, which confers sensibility on the muscles, and appears for this purpose, to be more abundantly supplied to the muscles of the face than any other sensitive nerve is to those of other parts.

Glossopharyngeal nerve arises by 5 or 6 filaments from the groove between the corpus olivare and restiforme; & escapes from scull at the innermost extremity in the jugular foramen.

Physiology of the Glosso-Pharyngeal Nerve.

The glosso-pharyngeal nerves, in the enumeration of the cerebral nerves by numbers according to the position in which they leave the cranium, are considered divisions of the eighth pair of nerves, in which term are included with them the pneumogastric and spinal accessory nerves.

Anatomy. The glosso-pharyngeal nerve appears to give filaments through its tympanic branch (Jacobsons nerve), to the fenestra ovalis, and fenestra rotunda, and the Eustachian tube; also, to the carotid plexus, and through the lesser petrosal nerve, to the spheno-palatine ganglion. After communicating either within or without the cranium, with the pneumogastric, and soon after it leaves the cranium, with the sympathetic, digastric branch of the facial, and the accessory nerve, the glosso-pharyngeal nerve parts into the 2 principal divisions indicated by its name, and supplies the mucous membrane of the posterior and lateral walls of the upper part of the pharynx, the Eustachian tube, the arches of the palate, the tonsils and their mucous membrane, and the tongue to as far forwards as the foramen caecum in the middle line, and to near the tip at the sides and inferior part.

Some experiments make it probable that the glosso-pharyngeal nerve contains, even at its

origin some motor fibres, together with those of common sensation and the sense of taste. For Volkmann and Hein when they divided the nerve within the skull, and then irritated its distal portion, saw movements of the pharynx and of the palate and its arches, which appeared to be due to contractions of the stylo-pharyngeus, and perhaps also of the palato-glossus muscles.

The experiments of Dr John Reid confirming those of Panizza and Longet, tend to the same conclusions; and their results probably express nearly all the truth regarding the part of the glosso-pharyngeal which is distributed to the pharynx. These results were that, —

1. Pain was produced when the nerve, particularly its pharyngeal branches, were irritated.

2. Irritation of the nerve before the giving off its pharyngeal branches, or of any of these branches, gave rise to extensive muscular motions of the throat and lower part of the face; but, when the nerve was divided, these motions were excited by irritating the upper or cranial portion, while irritation of the lower end, or that in connection with the muscles, was followed by no movement; so that these motions must have depended on a reflex influence transmitted to the muscles through other nerves by the intervention of the nervous centres.

3. When the function of the brain and

medulla oblongata were arrested by poisoning the animal with prussic acid, irritation of the glosso-pharyngeal nerve, before it was joined by any branches from the pneumogastric, gave rise to no movements in the muscles of the pharynx or other parts to which it was distributed; while, on irritating the pharyngeal branch of the pneumogastric, or the glosso-pharyngeal nerve after it had received the communicating branches just alluded to, vigorous movements of all the pharyngeal muscles and of the upper part of the œsophagus followed.

The most probable conclusion, therefore, may be that what motor influence the glosso-pharyngeal nerve may seem to exercise is due either to the filaments of the pneumogastric or accessory that are mingled with it, or to impressions conveyed through it to the medulla oblongata, and thence reflected to muscles through motor nerves, especially the pneumogastric, accessory, and facial. Thus the glosso-pharyngeal nerve excites through the medium of the medulla oblongata the actions of the muscles of deglutition. It is the chief centripetal nerve engaged in these actions; yet not the only one, for as Dr John Reid has shewn the acts are scarcely disturbed or

retarded

hen both the glosso-pharyngeal nerves are
ivided.

But besides being thus a nerve of common
ensation in the parts which it supplies,
nd a centripetal nerve through which impres
ions are conveyed to be reflected to the adjacent
uscles, the glosso-pharyngeal is also a nerve
f special sensation; being the gustatory nerve,
nerve of taste in all the parts of the tongue
which it is distributed.

After many discussions, the question,
which is the nerve of taste? — the lingual
ranch of the fifth, or the glosso-pharyngeal? —
may be most probably answered by stating
that they are both nerves of this special func=
tion, as has been proved by numerous ex=
periments.

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Physiology of the Pneumogastric, Accessory, Hypoglossal and Spinal Nerves; also the Sympathetic.

G. R. Gibb M.D.

10th January 1852

Pneumogastric arises by 10 or 15 filaments from the groove between the corpus olivare and corpus restiforme, immediately below the glosso-pharyngeal. Passes out of skull thro inner extremity of jugular foramen.

To illustrate

For Pneumogastric

Quain on Nerves plate 15. 16. 8
Quain on Arteries plate 2
electing from Wilson

For Accessory.

Quain on Nerves pl 15.
Morton Head & Neck. pl 1
electing from Wilson.

For Hypoglossal

Quain on Nerves pl 16
Morton on Head & Neck p 2 & 3

For Spinal Nerves Quain on Arteries pl 87

For Sympathetic Maunecs plate
Quain on Nerves pl 27 & 28

Physiology of Pneumogastric Nerve.

The pneumogastric nerve, nervus vagus, or par vagum, has, of all the cranial and spinal nerves the most various distributions, and influences the most various functions, either through its own filaments or those which, derived from other nerves, are mingled in its branches.

1st. The parts supplied by the branches of the pneumogastric nerve are as follows; by its pharyngeal branches, which enter the pharyngeal plexus, a large portion of the mucous membrane, and, probably, all the muscles of the pharynx; by the superior laryngeal nerve, the mucous mem: of the under surface of the epiglottis, the glottis, and the greater part of the larynx, and the crico thyroid muscle; the inferior laryngeal nerve, the mucous mem: & muscular fibres of the trachea, the lower part of the pharynx and larynx, and all the muscles of the larynx, except the crico-thyroid; by oesophageal branches, the mucous mem: and muscular coats of the oesophagus. Moreover, the branches of the pneumogastric form a large portion of the supply of nerves to the heart and great arteries through the cardiac nerves, derived from both the trunk and the recurrent nerve; to the lungs, through both the anterior and posterior pulmonary plexuses; and to the stomach by its terminal branches passing over the walls of that organ.

From the parts thus enumerated as receiving
nerves from the pneumogastric, it might be assumed
that it is a nerve of mixed function, both sensi
tive and motor. Experiments prove that it is so
from its origin, for the irritation of its ~~nerves~~
roots, even within the cranium, produces both
pain and convulsive movements of the larynx
and pharynx, and when it is divided within
the skull the same movements follow the irrita-
tion of the distal portion, showing that they are
not due to reflex action. Similar experiments prove
that, through its whole course, it contains both
sensitive and motor fibres, but after it has
merged from the skull, and, in some instances, even
sooner, it enters into so many anastomoses that
it is hard to say whether the filaments it contains
are, from their origin, its own or whether they
are derived from other nerves combining with it.
This is particularly the case with the filaments
of the sympathetic nerve, which are abundantly
added to nearly all the branches of the pneumogastric.
Next to the sympathetic nerve, that which most
importantly communicates with the pneumogastric is
the accessory nerve, whose internal branch joins
its trunk and is lost in it.

Properly, therefore, the pneumogastric might
be regarded as a triple mixed nerve; having, out

its own sources, motor, sensitive, and sympa=
thetic or ganglionic nerve fibres; and to this nat=
ural complexity it adds that which it derives from
the reception of filaments from the sympathetic acces=
sory, and cervical nerves, and, probably the
glossopharyngeal and facial.

The most probable account of the particular func
tions which the branches of the pneumogastric nerve
discharge in the several parts to which they are dis=
tributed may be drawn from Dr John Reids exper
ments on dogs. They show that, —

1. The pharyngeal branch is the principal, if not
the sole, motor nerve of the pharynx and soft
palate, and is most probably wholly motor; a
part of its motor fibres being derived from the inter
al branch of the accessory nerve.

2. The inferior laryngeal nerve is the motor nerve
of the larynx, irritation of it producing vigorous
movements of the arytenoid cartilages; while ir=
ritation of the superior laryngeal nerve gives rise
to no action in any of the muscles attached to
the arytenoid cartilages, but merely to contractions
of the crico-thyroid muscle.

3. The superior laryngeal nerve is chiefly sensitive;
the inferior, for the most part, motor; for division
of the recurrent nerves puts an end to the motions
of the glottis, but without lessening the sensibility
of the mucous membrane; and division of the superior

yngeal nerves leaves the movements of the glottis
affected, but deprives it of its sensibility.

3. The motions of the oesophagus are dependant
on motor fibres of the pneumogastric, and are probably
excited by impressions made upon sensitive fibres
of the same; for irritation of its trunk excites
motions of the oesophagus, which extend over the
cardiac portion of the stomach; and division of
the trunk paralyses the oesophagus, which then
becomes distended with the food.

5. The cardiac branches of the pneumogastric
nerve are one, but not the sole, channel through
which the influence of the central organs and of
mental emotions is transmitted to the heart.

6. The pulmonary branches form the principal,
but not the only, channel by which the impressions
on the mucous surface of the lungs that excite res-
piration, are transmitted to the med. oblong.
Dr Reid was unable to determine whether they con-
tain motor fibres; but we have reason to believe
that they do so —

From these results, and what has been
before said, the share which this nerve takes in
the functions of the parts to which it sends bran-
ches, may be understood, as follows: —

1. In deglutition the motions of the pharynx are
of the reflex kind. The stimulus of the food, or
other substance to be swallowed, acting on the filaments

the glosso-pharyngeal, the filaments of the superior laryngeal given to the pharynx, and the cervical nerves, is conducted to the medulla oblongata, but it is reflected, chiefly through the pneumogastric the muscles of the pharynx, and perhaps, also of the soft palate.

2. In the functions of the Larynx, the sensitive filaments of the pneumogastric supply that acute sensibility by which the glottis is guarded against the ingress of foreign bodies, or of irrespirable gases. The contact of these stimulates the filaments of the superior laryngeal branch of the pneumogastric; and the impression conveyed to the medulla oblongata, whether it produces sensation or not, is reflected to the filaments of the recurrent or inferior laryngeal branch, and excites contraction of the muscles that close the glottis. Both these branches of the pne: gas: co-operate also in the production and regulation of the voice. And both also co-operate in the actions of the larynx in the acts of expiration & inspiration and in those of coughing & other forcible respiratory movements.

3. It is partly through their influence on the sensibility and muscular movements in the larynx that the pneu: gas nerves exercise so great an influence on the respiratory process, and that the division of both the nerves is commonly fatal. To determine how death is in these cases produced has been the object of numerous & often contradictory experiments.

After division of both the nerves, the respiration at once becomes slower, the number of respirations in given time, being diminished one half.

Again, division of both trunks, or of both their recurrent branches, is often very quickly fatal in many animals; but in old animals the division of the recurrent nerves is not generally fatal, and that of both the pneumogastric trunks is not always fatal, and when it is so, the death ensues slowly. In the cases of slower death after division of both trunks, the lungs are commonly found gorged with blood, oedematous, or nearly solid, or with a kind of low pneumonia, and with their bronchial tubes full of frothy, fluid blood, and mucus, changes to which, in general, the death may be proximately ascribed. These changes are due perhaps in part to the influence which the pneumogastric nerves exercise on the chemical process of respiration in the lungs, and the movements of the air cells and bronchii.

4. The influence of the pneumogastric nerves on the movements of the oesophagus & stomach, the secretion of gastric fluid, the sensation of hunger, absorption from the stomach, & the action of the heart, has been formerly described. But it is now like the sympathetic (from its structure) than that of a cerebro-spinal nerve.

Spinal Accessory, arises by several filaments from the side of the spinal cord as low down as the 4th or 5th cervical nerve, and ascends behind the ligamentum denticulatum, and between the anterior & posterior roots of the spinal nerves, to the foramen lacerum posterius.

Physiology of the Accessory Nerve.

The principal branch of the accessory nerve, its external branch, supplies the sterno-mastoid and trapezius muscles; and, though pain is produced by irritating it, is composed almost exclusively of motor fibres. It might appear very probable therefore, that the internal branch, which is added to the trunk of the pneumogastric just before the giving off of the pharyngeal branch, is also motor; and that through it the pneumogastric nerve derives part of the motor fibres which it supplies to the muscles just enumerated.

And further since the pneumogastric has a ganglion just above the part at which the internal branch ~~joins~~ of the accessory nerve joins its trunk, a close analogy may seem to exist between these 2 nerves and the spinal nerves with their anterior and posterior roots. Vrolik states in the Chimpanzee the internal branch of the accessory does not join the pneumogastric at all, but goes directly to the larynx.

It may be concluded that the accessory gives to the pneumogastric nerve some of the motor filaments which pass, with the laryngeal branches, to the muscles of the larynx, especially to the crico-thyroid.

It is not certain whether, besides these, the accessory gives to the pneumogastric any other

motor filaments. It is however, certain that it does not supply all the motor filaments which the branches of the pneumogastric contain; for division of the pneumogas: produces a much more extensive paralysis of motion in all the parts that it supplies than division of the accessory or its internal branch does: especially in regard to the larynx (and other respiratory organs; almost the only effects of destruction of the accessory are loss of voice, and panting in great efforts.

Among the roots of the accessory nerve, the lower, arising from the spinal cord, appear to be composed exclusively of motor fibres, and to be destined entirely to the trapezius and sterno-mastoid muscles; the upper fibres, arising from the medulla oblongata, contain many sensitive as well as motor fibres, and these are included in the internal branch which joins the pneumogastric.

As a respiratory nerve, under the influence of the Med: oblong: the accessory has been often observed to conduct impressions exciting movements necessary to respiration in the sterno-mastoid and trapezius muscles, after these muscles have ceased to move under the influence of the will. They may thus act whenever any

Hypoglossal arises from the groove between the corpus olivare and corpus pyramidale by 10 or 15 filaments, which being collected into 2 bundles, escape from the cranium through the anterior condyloid foramen.

the parts of the brain above the med. oblong. cease to be capable of conveying impressions; for then the will cannot act on these or any other muscles, though they are still amenable to the reflex influence of the medulla oblongata.

Physiology of the Hypoglossal Nerve.

The hypoglossal, or ninth nerve, or motor linguae has a peculiar relation to the muscles connected with the hyoid bone, including those of the tongue. It supplies through its descending branch (descendens noni), the sterno hyoid, sterno thyroid, and omo hyoid; through a special branch the thyro-hyoid, and through its lingual branches the genio-hyoid, styloglossus, hyoglossus, and ranio hyoglossus. It contributes, also, to the supply of the submaxillary gland.

The function of the hypoglossal nerve is, perhaps exclusively motor. Irritation of it within the skull produces little if any pain; but since pain is sometimes produced, it may be supposed that the nerve has either some sensitive fibres from its origin, or some which are taking a retrograde course through it to the brain. As a motor nerve, its influence on all the muscles enumerated, is shown by their

convulsions when it is irritated, and by their loss of power when it is paralysed. The effects of the paralysis of one hypoglossal nerve are, however, not very striking on the tongue. Often in cases of hemiplegia involving the functions of the hypoglossal nerve, it is not possible to observe any deviation in the direction of the protruded tongue; probably because the tongue is so compact and firm that the muscles of either side, their insertion being nearly parallel to the median line, can push it straight forwards or turn it for some distance towards either side.

The plexus formed between the branches of the descendens noni and those of the 2nd & 3rd cervical nerves serves not only to distribute filaments of the hypoglossal to the depressor muscles of the hyoid bone, but to admit into the descendens noni, filaments of the cervical nerves which take a recurrent course through it, and of which some return to the med: oblongata through the trunk of the hypoglossal and others go to the tongue through its lingual branches. Hence, and from other connections with the cervical nerves higher up, the hypoglossal nerve has ample borrowed sensibility.

Physiology of the Spinal Nerves.

Very little need be added to what I have already said of these nerves, in my lecture on the Spinal cord and its nerves.

Magendie and Bernard alone dissent from the opinion that the anterior roots of the spinal nerves are formed exclusively of motor fibres. They hold that certain sensitive fibres, after traversing the posterior roots and ganglia, assume a recurrent course through the anterior roots, and thus give them a slight degree of sensibility which is lost when the posterior roots are divided, but which is clearly indicated by signs of pain when the anterior roots, or those portions of them that are connected with the ganglia are irritated.

Beyond the ganglia all the spinal nerves appear to be mixed nerves, and to contain as well sympathetic filaments, as those of sensation and motion derived through their own roots.

Of the functions of the ganglia of the spinal nerves nothing is known. That they are not the reflectors of any of the ascertained reflex actions through the spinal nerves, is shewn by the reflex movements ceasing when the posterior roots are divided between the ganglia and the spinal cord.

Physiology of the Sympathetic N.

The sympathetic nerve, or sympathetic system of nerves, obtained its name from the opinion that it is the means through which are effected the sympathies in morbid action which distant organs manifest. It has also been called the visceral nerve, because it is principally distributed among the organs of the 3 Chief visceral systems, the thoracic, abdominal and pelvic; and the nervous system of organic life, in the supposition that it alone, as a nervous system, influences the organic processes.

The general differences between the fibres of the cerebro-spinal and sympathetic nerves have been already given; and although such differences exist, and are visible in selected filaments of each system of nerves, yet they are neither so constant nor of such a kind, as to warrant the supposition, that the different modes of action of the 2 systems can be referred to the different structures of their fibres. It is rather probable that the laws of conduction by the fibres are in both systems the same, and that the differences manifest in the modes of action of the systems are due to the multiplication and separation of the nervous centres of the sympathetic: ganglia, or nervous centres, being placed in connection with the fibres of the

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There are 5 sympathetic ganglia in the head: viz

Ganglion of Ribes	1
Ciliary or lenticular ganglion	4
Spheno palatine or Meckels ganglion	9
Otic, or Arnolds ganglion	
Submaxillary ganglion.	20

There are 3 in the neck, cupum, middle & inferior
12 in the dorsal region
4 in the lumbar do
4 or 5 in the sacral do

sympathetic in nearly all parts of their course.

The sympathetic system is arranged in 2 principal divisions, each of which consists of ganglia and connecting fibres.

The 1st division may include the ganglia seated on, or close to, cerebral and spinal nerves, with the filaments issuing from them. ✝

The 2nd may comprise the ganglia on the 2 main branches of the sympathetic, and on its branches in the visceral cavities.

To the first belong the ophthalmic, spheno-palatine otic, and submaxillary ganglia on the divisions of the 5th nerve; and probably the ganglia on the glosso-pharyngeal and pneumogastric nerves, and on the posterior roots of the spinal nerves; for from all these, fibres appear to originate which in structure, resemble those derived from the proper ganglia of the sympathetic, and are distributed to the same parts.

To the second division belong the ganglia arranged in a continuous line along the sides of the vertebrae, with their connecting cords, which make up what have been generally called the trunks of the sympathetic nerve; and all the ganglia placed irregularly on the branches of the sympathetic distributed to the viscera. Of the former the number and proportion correspond generally to the vertebrae; of the latter, to the development of the viscera. Shaw Mavis's plate

The structure of all these ganglia appears to be essentially similar; all containing 1st, nerve fibres traversing them; 2nd ly nerve fibres originating in them; 3rd ly nerve or ganglion corpuscles, giving origin to these fibres; and 4th ly other corpuscles that appear free. And in the trunks, and thence proceeding branches of the sympathetic, there appear to be always, 1st, fibres which arise in its own ganglia; 2nd ly, fibres derived from the ganglia of the cerebral and spinal nerves; 3rd ly, fibres transmitted from the brain and spinal cord through the roots of the nerves.

Of the Cause of the filaments of the Sympathetic

The following appears to be nearly all that is known. Of those derived from the ganglia on the cerebral nerves some may pass towards the brain; for in the trunks of the nerves, between the ganglia & the brain, fine filaments like those of the sympathetic are found.

Of the fibres that arise in the spinal ganglia some appear to pass into the posterior branches of the spinal nerves, and to be distributed to them; the rest pass through the branches by which the spinal nerves communicate with the trunks of the sympathetic, and then entering the sympathetic are distributed with its branches to the viscera. With these, also, a certain number of the large ordinary cerebro-spinal nerve fibres, after traversing the ganglia, pass into the sympathetic.

of the fibres derived from the ganglia of the Sympathetic
ic itself, some go straightway towards the viscera
ey must pass through the branches of communication
between the sympathetic and the anterior branch
s of the spinal nerves, and, joining these spi=
nal nerves, proceed with them to their respec=
tive seats of distribution, especially to the more
sensitive parts.

Thus through these communicating branches,
which have been generally called roots or origins
of the sympathetic nerve, an interchange is
effected between all the spinal nerves and the
sympathetic trunks; all the ganglia also, which
are seated on the cerebral nerves, have roots
(as they are called) through which filaments of
the cerebral nerves are added to their own. So
that, probably, all sympathetic nerves contain
some intermingled cerebral or spinal nerve-
fibres; and all cerebral and spinal nerves some
filaments derived from the sympathetic system
or from ganglia. But the proportions in which
these filaments are mingled are not uniform.

The nerves of voluntary muscles contain in
their trunks a majority of large or cerebro spinal
nerve-fibres. The nerves of the skin and of most
sensitive mucous membranes, contain for the
most part, equal numbers of both large and
fine fibres. In the nerves of invaluntary muscles
and in those of the less sensitive muc: mem: there
is a great preponderance of the fine filaments.

The Physiology of the Sympathetic system, is obscure unless when illustrated by that of the cerebro spinal system.

It may be stated generally as nearly certain that the sympathetic nerve fibres are simple conductors of impressions, as those of the cerebro spinal system are, and that the ganglionic centres have (each in its appropriate sphere) the like power both of conducting and communicating impressions. Their power of conducting impressions is sufficiently shown in ordinary diseases, as when any of the viscera, usually unfelt, gives rise to sensations of pain, or when a part not commonly subject to mental influence is excited or retarded in its actions by the various conditions of the mind; for in all these cases impressions must be conducted to and fro through the whole distance between the part and the spinal cord and brain. So also, in experiments, now more than sufficiently numerous, irritations of the semilunar ganglia, the splanchnic nerves, the thoracic, hepatic, and other ganglia & nerves, have elicited expressions of pain, and have excited movements in the muscular organs supplied from the irritated part.

With the exception that conduction is effected more slowly through the proper sympathetic

fibres or their ganglia, it is probable that the laws of conduction of impressions are the same in both cerebro-spinal and sympathetic systems.

Complex as the Sympathetic System, is, taken as a whole, it presents in each of its parts a simplicity not to be found in the cerebro spinal system; for each ganglion with afferent and efferent nerves forms a simple nervous system, and might serve for the illustration of all the nervous actions with which the mind is unconnected.

The general processes which the Sympathetic appears to influence are those of involuntary motion, secretion and nutrition.

Many movements take place involuntarily in parts supplied with cerebro spinal nerves, as the respiratory and other spinal reflex actions; but the parts principally supplied with sympathetic nerves are usually capable of none but involuntary movements, and when the mind acts on them at all, it is only through the strong excitement or depressing influence of some passion, or through some voluntary movement with which the actions of the involuntary part are commonly associated. The heart, stomach, and intestines are examples of these statements; for the heart & stomach

though supplied in large measure from the pneumogastric nerves, yet probably derive through them few filaments, except such as have arisen from their ganglia, and are therefore of the nature of sympathetic fibres.

The parts which are supplied with motor power by the sympathetic nerve continue to move, though more feebly than before, when they are separated from their natural connection with the rest of the sympathetic system & wholly removed from the body. Thus the heart, after it is taken from the body, continues to beat in Mammalia for 1 or 2 minutes, in Reptiles and Amphibia for hours; and the peristaltic motions of the intestines continue under the same circumstances. Hence the motions of the parts supplied with nerves from the sympathetic are shown to be in a measure, independant of the brain & spinal cord.

Of a muscle supplied with cerebro-spinal nerves, only that fasciculus acts to which the stimulus of irritation is applied. But if one supplied from the sympathetic nerve, the contraction commences more slowly, but continues longer than that supplied by the cerebro-spinal system.

It seems to be a general rule, at least in

animals that have both cerebro spinal and sympathetic nerves much developed, that the involuntary movements excited by stimuli conveyed through ganglia are orderly and like natural movements, while those excited through nerves without ganglia are convulsive and disorderly. As the muscles of respiration are maintained in uniform rythmic action by the reflecting and combining power of the med: oblong:, so probably are those of the heart, stomach, and intestines by their sensual ganglia.

The mode in which the influence of the Symp: nerve is exercised in Nutrition and Secretion is unknown; and equally unknown whether it be exercised through Symp: or cerebro spinal fibres, or both.

The apparent distribution of both kinds of fibres to all sensitive and secreting parts, & the impossibility of isolating them, make the difficulty of deciding this point appear insuperable.

The difficulty is much greater in the higher than in the lower Vertebrata; for it would appear that in the same proportion as the centres of the cerebro-spinal system are developed, so is its connection with the processes of organic life more intimate.

(Cuvierian page 468)

36

Voice and Speech.

Geo. D. Gibb M.D.

12th January 1852

To illustrate

Drawings in Kirkes - figs 38. 39 & 40 drawn on a
large scale and coloured.
Preparations of Larynx and Cartilages
dissections of ditto.
Drawing of throat of animals of Howling Monkey -
Pitt Museum
Boerhaaves Physiology plate 19.

This lecture was interrupted 20 min before the
hour by Dr Macdonnell, so I could
only get through basic -

Of Voice and Speech

In nearly all air-breathing Vertebrate animals there are arrangements for the production of sound or voice, in some part of the respiratory apparatus. In many animals, the sound admits of being variously modified and altered during and after its production; and, in man, one of the results of such modification is Speech.

In all the air-breathing Vertebrata, the production of sound depends upon the passage of air through certain portion of the respiratory tubes; which is so constructed as to set it in vibration, as it passes forth from the lungs. —

In Reptiles, the vibrating apparatus is situated at the point, where the trachea opens into the front of the pharynx; it is of very simple construction, however, being only composed of a slit bounded by contractile lips; and few of the animals of this class can produce any other sound than a hiss, which owing to the great capacity of their lungs, is often very much prolonged. —

In Birds the situation of the vocal organ is very different. The trachea opens into the front of the pharynx, as in Reptiles, by a mere slit; the borders of which have no other movement than that of approaching one another, so as to close the aperture when necessary. This appears to be the instrument for regulating the ingress & egress of air,

in conformity with the wants of the respiratory func=
tion. The vocal larynx of Birds is situated at
the lower extremity of the trachea, just where it sub=
divides into the bronchial tubes; and it is of very
complex construction, especially in the singing birds.
In Mammalia, on the other hand, the vocal organ
and the regulator of the respiration are united in the
larynx, which is situated at the top of the trachea.
There are few, if any, of this class, which have not
some vocal sound; but the variety and expres=
siveness which can be given to it, differ consid=
erably in the several orders; being by far the
greatest in Man, who alone, there is reason to
decline, has the power of producing articulate sounds
or proper language.

The Larynx is built up, as it were, upon
the Cricoid cartilage (point to it pg 39. 9.), which surm=
ounts the trachea, and which might be considered
as its highest ring, modified in form, its depth
from above downwards being much greater poste=
riorly than anteriorly. This is embraced, as it were,
by the Thyroid cartilage (show 8. drawing); which is
articulated to the sides of the Cricoid by its
lower horns, round the extremities of which
it may be considered to rotate, as on a pivot.
In this manner, the front of the Thyroid carti=
lage may be lifted up, or depressed, by the
muscles which act upon it; whilst the position
of its posterior part is but little changed. Upon

the upper surface of the back of the Cricoid cartilage, are seated
two small Arytenoid cartilages (2.); these are so tied
to the Cricoid by a bundle of strong ligaments (13.),
as to have a sort of rotation upon an articulating
surface, which enables them to be approximated
or separated from each other, — their inner edges being nearly parallel in the first case, but
slanting away from each other in the second. To
the summit of these cartilages are attached the
Chordae vocales, or vocal ligaments (3.) composed
of yellow fibrous or elastic tissue. These stretch
across to the front of the Thyroid cartilage; &
it is upon their condition and relative situation,
that the absence or production of vocal tones, &
all their modifications of pitch, depend. They
are rendered tense by the depression of the front
of the Thyroid Cartilage, and relaxed by its elevation; by which action the pitch of the tones
is regulated. But for the production of any
vocal tones whatever, they must be brought
into a nearly parallel condition, by the mutual
approximation of the points of the arytenoid
cartilages to which they are attached; whilst
in the intervals of vocalization, these are separated, and the rima-glottidis or fissure between
the Chordae vocales, assumes the form of a
narrow V, with its point directed backwards.

Mode of Production of the Human Voice.

It has been proved, by observations on living subjects, as well as by experiments on the larynx taken from the dead body, that the sound of the human voice is the result of the inferior laryngeal ligaments, or vocal cords, which bound the glottis, being thrown into vibrations by currents of expired air impelled over their edges. Thus, if a free opening exist in the trachea, the sound of the voice ceases, but returns on the opening being closed.

Late history of case, shewn by Dr Stokes when I was in Dublin – in 1848 –

An opening above into the air passages above the glottis, on the contrary, does not prevent the voice being formed. Magendie, also has shewn that the voice is not lost, though the epiglottis, the superior ligaments of the larynx, and the upper part of the arytenoid cartilages be injured.

The same may be observed in cases of disease; and in injuries, when the vocal cords are exposed they may be seen vibrating during the emission of sound. Injury of the laryngeal nerves supplying the muscles which move the vocal cords puts an end to the formation of vocal sounds; and when these nerves are divided on both sides, the loss of voice is complete. Moreover, by forcing a current of air through the larynx in the dead subject, clear vocal sounds are produced

through the epiglottis, the upper ligaments of the larynx, the ventricles between them and the inferior or vocal ligaments, and the upper part of the arytenoid cartilages, being all removed; provided the vocal cords remain entire, with their points of attachment, and are kept tense and so approximated that the fissure of the glottis may be narrow.

The vocal ligaments, therefore may be regarded as the proper organs of the mere voice: the modifications of the voice are effected by other parts as well as by them. Their structure as already given, is adapted to enable them to vibrate like tense membranes, for they contain a large quantity of elastic tissue; and they are so attached to the cartilaginous parts of the larynx that they can be made tense either by the depression of the thyroid cartilage (Figs 38. 39. 8.), towards the cricoid cartilage (38 & 39. 9), as already said, by means of the crico-thyroid muscles (38. 10); or by the retraction of the arytenoid cartilages (39. 2), which are moved backwards by the posterior crico-arytenoid muscles (39. 4.), at the same time that they are approximated by the posterior arytenoid (6). The length of the fissure of the glottis (1) depends on the degree to which the cords are thus stretched; and their degree of tension probably depends not only on the degree in which their stretching is resisted by their proper tissue, but also, in some measure, on the action of the

thyro-arytenoid muscles, which are closely connected to them along their whole length.

The aperture of the glottis is narrowed by the approximation of the arytenoid cartilages, which is effected by the arytenoid muscles: it is dilated by the lateral crico-arytenoid (5), which draw the arytenoid cartilages asunder.

The experiments of the Rev. Mr Willis on instruments made in imitation of the larynx, have shown that, besides being made tense, the vocal cords, in order to produce a proper vocal sound, must have their inner edges parallel. In the ordinary position of the glottis, during respiration without vocalization, he supposes that the lips of the glottis are inclined from each other (as at A, fig 60, which is an imaginary transverse perpendicular section of the vocal tube), and that to produce voice they must assume the parallel state (as at pink B, fig 60); and he attributes to the thyro-arytenoid muscles the office of placing the ligaments in this position.

In vocalizing the ligaments vibrate in their entire breadth, and with them the thyro-arytenoid muscles, and (to an extent corresponding to the force with which they vibrate,) the adjacent elastic tissues of the larynx and other parts, and the air in and beyond the respiratory passages. For the deepest notes, the vocal

ligaments are much relaxed by the approximation of the thyroid to the arytenoid cartilages.

The lips or margins of the glottis are, in this state of the larynx, not only devoid of tension — they are, when at rest, even wrinkled — but they become stretched by the current of air, and thus acquire the degree of tension necessary for vibration. From the deepest note thus produced, the vocal sounds may be raised about an octave by allowing the vocal cords to have the slight degree of tension which the elastic crico-thyroid ligament can give them, by drawing the thyroid cartilage towards the cricoid. The medium state, in which the cords are neither relaxed and wrinkled nor stretched, is the condition for the middle notes of the natural voice, and those which are most easily produced in singing. (The ordinary tones of the voice in speaking are intermediate between these and the deep bass notes.) The higher notes of the natural voice are produced by the lateral compression of the vocal cords, and the narrowing of the space between them by means of the thyro-arytenoid muscles; and further, by increasing the force of the current of air.

In the quiescent state, the aperture of the glottis is widely open and somewhat triangular, the base of the triangle corresponding to the space between the separated arytenoid cartilages. In inspiration the glottis is slightly dilated, in expiration

Contracted;

and at the moment of the emission of sound it is more narrowed, the margins of the arytenoid cartilages being brought into contact, and the edges of the vocal cords approximated and made parallel. The degree of approximation usually corresponds to the height of the note produced; but probably not always, for the width of the aperture has no essential influence on the height of the note, as long as the vocal cords have the same tension; only, with a wide aperture, the tone is more difficult to produce, and is less perfect, the rushing of the air through the aperture being heard at the same time.

No true vocal sound is produced at the posterior part of the aperture of the glottis, that viz. which is formed by the space between the arytenoid cartilages.

Vocal sounds can be produced not only when the lips of the glottis are separated by a narrow interval, but even when to the eye they appear to be in contact, especially if the vocal cords are much relaxed; in which case the vibrations of the lips of the glottis are very strong. The notes emitted in such a condition of the glottis are stronger and fuller; but, provided the length of the cords be the same, and the tension in both cases equally slight, the height of the note is not influenced by the cords being in contact,

by their being separated by a narrow interval.

The epiglottis, by being pressed down so as to cover the superior cavity of the larynx, serves to render the notes deeper in tone, and at the same time somewhat duller, just as covering the end of a short tube placed in front of a caoutchouc tongues lowers the tone. In uttering any deep notes during life, we evidently employ the epiglottis in this way.

Application of the Voice in Singing and Speaking

The notes of the voice thus produced may observe 3 different Kinds of sequence. The first is the monotonous, in which the notes have all nearly the same pitch, as in ordinary speaking; the variety of the sounds of speech being owing to articulation in the mouth. The second mode of sequence is the successive transition from high to low notes, and vice versâ, without intervals; such as is heard in the sounds, which as expressions of passion accompany crying in men, and the howling & whining of dogs. The third mode of sequence of the vocal sounds is the musical, in which each sound has a determinate number of vibrations, and the number of vibrations in the successive sounds have the same relative proportions as characterise the notes of the musical scale.

It has been fully proved, by the researches of Willis, Muller and others, that the action of the vocal ligaments, in the production of sound, bears no resemblance to that of vibrating strings; and that it is not comparable to that of the mouth piece of the flute pipes of the Organ: but that it is, in all essential particulars, the same with that of the reeds of the Hautboy or Clarionet, or the tongues of the Accordion or Concertina. All the phenomena attending the production of Musical tones are fully explicable on this hypothesis; except the production of falsetto notes, which has not yet been clearly accounted for. — The power which the Will possesses, of determining, with the most perfect precision, the exact degree of tension which these ligaments shall receive, is extremely remarkable. Their average length in the Male, in the state of repose is estimated by Mueller at about 73-100ths of an inch; whilst, in the state of greatest tension, it is about 93-100ths; the whole difference, therefore, is not above 20-100ths, or one fifth of an inch. In the female glottis, their average dimensions are about 57-100ths and 63-100ths, respectively; so that the difference is here only 12-100ths, or less than one-eighth, of an inch.

The Compass of the voice in different individuals comprehends 1, 2, or 3 octaves; in singers, — that is, in persons apt for singing, — it extends to 2 or 3 octaves. But the male & female voices commence and end at different points of the

musical scale. The lowest note of the female voice is about an octave higher than the lowest of the male voice; the highest note of the female voice about an octave higher than the highest of the male. The compass of the male and female voices taken together, or the entire scale of the human voice, includes about 4 octaves. The principal difference between the male and female voice is, therefore in their pitch; but they are also distinguished by their tone, — the male voice is not so soft.

The voice presents other varieties besides the male and female; there are 2 kinds of male voice, technically called the bass and tenor, and two kinds of female voice, the contr'alto and soprano, all differing from each other in tone. The bass voice usually reaches lower than the tenor, and its strength lies in the low notes; while the tenor voice extends higher than the bass. The contralto voice has generally lower notes than the soprano, and is strongest in the lower notes of the female voice; while the soprano voice reaches higher in the scale. But the difference of compass, and of power in different parts of the scale, are not the essential distinctions between the different voices; for bass singers can sometimes go very high, and the contralto frequently sings the high notes like soprano singers.

It is on account of the greater length of the vocal cords, that the pitch of the voice is much lower in Man than in woman, being in the ratio of 3 to 2. The size of the larynx is the same

the Boy, and girl up to the age of 14 or 15 years, when
former undergoes a rapid increase, and the latter
mains stationary. Hence it is that Boys, as well
Girls, and women, sing treble; whilst men sing
enor, which is an octave lower than the treble; or
ass which is several notes lower still.

The loudness of the voice depends in
part upon the force with which the air is expelled
from the lungs; but the variations in this respect
which exist among different individuals, seem
partly due to the degree in which its resonance is
increased by the vibration of the other parts of the
larynx, and of the neighbouring cavities. In the
Howling Monkeys of S. America, there are several
pouches opening from the larynx, which seem
destined to increase the volume of tone that
issues from it; one of these is excavated in the
substance of the hyoid bone itself. Although
these Monkeys are of inconsiderable size, yet
their voices are louder than the roaring of lions,
and are distinctly audible at the distance of
two miles; and when a number of them are con-
gregated together, the effect is terrific.

As I have just said Boys voices are alto
and soprano, resembling in pitch those of women
but differing somewhat from them in tone, and
louder. But when puberty arrives, the larynx
undergoes a change, and the boys voice becomes
bass or tenor. While the change of form is taking
place,

the voice is said to crack; it becomes imperfect, frequently hoarse and croaking, and is unfitted for singing until the new tones are brought under command by practice. In eunuchs, who have been deprived of the testes before puberty, the voice does not undergo this change. The voice of most old people is deficient in tone, unsteady, and more restricted in extent: the 1st defect is owing to the ossification of the cartilages of the larynx & the altered condition of the vocal cords; the want of steadiness arises from the loss of nervous power & command over the muscles; the result of which is a tremulous motion. These 2 causes combined render the voice of old people void of tone, unsteady, bleating and weak.

Most persons, particularly men, have the power if at all capable of singing, of modulating their voices through a double series of notes of different character. Namely, the notes of the natural voice, or chest-notes, and the falsetto notes.

The natural or chest notes, are produced by the ordinary vibrations of the vocal cords. The mode of production of the falsetto notes is still obscure and the question is not yet settled. By Muller they are thought to be due to vibrations of only the inner borders of the vocal cords.

The length of the larynx and trachea below the vocal ligaments has, according to Mueller, no perceptible influence in the tone or pitch of the voice.

The arches of the palate and the uvula become contracted during the formation of the higher notes;

but their contraction is the same for a note of given weight, whether it be falsetto or not; and in either case the arches of the palate may be touched with the finger, without the note being altered. Their action, therefore, in the production of the higher notes, seems to be merely the result of involuntary associate nervous action, excited by the voluntarily increased exertion of the muscles of the larynx. The office of the Ventricles of the Larynx is evidently to afford a free space for the vibrations of the lips of the glottis: they may be compared with the cavity at the commencement of the mouth-piece of trumpets, which allows the free vibration of the lips.

Speech —

Besides the musical tones formed in the larynx, a great number of other sounds can be produced in the vocal tube, between the glottis and the external apertures of the air passages, the combination of which sounds into different groups to designate objects, properties, actions, &c, constitutes Language. The languages do not employ all the sounds which can be produced in this manner, the combination of some with others being often difficult. Those sounds which are easy of combination enter, for the most part, into the formation of the greater number of languages.

Each language contains a certain number of such sounds, but in no one are all brought together. On the contrary, different languages are characterised by the prevalence in them of certain classes of these sounds, while others are less frequent or altogether absent.

The sounds produced in speech, or articulate sounds, are commonly divided into vowels & consonants; the distinction between which are that the sounds of the former are generated in the Larynx, while those for the latter are produced by interruption of the current of air in some part of the air-passages above the Larynx. The term Consonant has been given to these because several of them are not properly sounded, except consonantly with a vowel. Thus if it be attempted to pronounce aloud the Consonants b. d. and g, or their modifications p. t. k, the intonation only follows them, in their combination with a vowel.

All the vowels can be expressed in a whisper without vocal tone, that is, mutely. These mute vowels differ, however, in some measure, as to their mode of production, from the consonants. All the mute consonants are formed in the vocal tube above the glottis, or in the cavity of the mouth or nose, by the mere rushing of the air between surfaces differently modified in disposition. But the sound of the vowels, even when mute, has its source in the glottis, though the vocal cords are not thrown into the vibra-

tions

necessary for the production of voice; and the sound seems to be produced by the passage of the current of air between the relaxed vocal cords. The same nasal-sound can be produced in the larynx when the mouth is closed, the nostrils being open, and the utterance of all vocal tone avoided. This sound when the mouth is open, is so modified, by varied forms of the oral cavity, as to assume the characters of the vowels a. e. i. o. u, in all their modifications.

The cavity of the mouth assumes the same form for the articulation of each of the mute vowels as for the corresponding vowel when voc-alized; the only difference in the 2 cases lies in the kind of sound emitted by the larynx. Kratzenstein and Kempelen have pointed out that the conditions necessary for changing one and the same sound into the different vowels are differences in the size of the two parts — the oral canal and the oral opening; and the same is the case with regard to the mute vow-els. By oral canal, Kempelen means here the space between the tongue and palate: for the pronunciation of certain vowels both the opening of the mouth and the space just mentioned are wide; for the pronunciation of other vowels both are contracted; and for others one is wide, the other contracted. Admitting 5 degrees of size, both of the opening of the mouth and of the space between the tongue and palate, Kempelen thus states the dimensions of these parts for the following vowel sounds: —

Vowel.	Sound.	Size of oral opening.	Size of oral canal.
a	as in 'far'	5	3
a	" 'name'	4	2
e	" 'theme'	3	1
o	" 'go'	2	4
oo	" 'cool'	1	5

Another important distinction in articulate sounds is that the utterance of some is only of momentary duration, taking place during a sudden change in the conformation of the mouth, and being incapable of prolongation by a continued expiration. To this class belong b. p. d, and the hard g. In the utterance of other consonants the sounds may be continuous; they may be prolonged, ad libitum, as long as a particular disposition of the mouth and a constant expiration are maintained. Among these consonants are h. m. n. f. s. r. l. Corresponding differences in respect of the time that may be occupied in their utterance exist in the vowel-sounds, & principally constitute the differences of long & short syllables. Thus the a as in "far" and "fate," the o as in "go" and "fort," may be indefinitely prolonged; but the same ~~words~~ vowels (or more properly different vowels expressed by the same letters), as in "can" and "fact," in "dag" and "ratten", cannot be prolonged.

(Then if time)

The peculiarity of speaking, to which the term ventriloquism is applied, appears to consist merely in the varied modification of the sounds produced in the larynx, in imitation of the

modifications which voice ordinarily suffers from distance, &c. From the observations of Muller and Colombat it seems that the essential mechanical parts of the process of ventriloquism consist in taking a full inspiration, then keeping the muscles of the chest and neck fixed, and speaking with the mouth almost closed, and the lips and lower jaw as motionless as possible, while air is very slowly expired through a very narrow glottis; care being taken also, that none of the expired air passes through the nose. But, as observed by Muller much of the ventriloquist's skill in imitating the voices coming from particular directions consists in deceiving other senses than hearing. We never distinguish very readily the direction in which sounds reach our ear; and, when our attention is directed to a particular point, our imagination is very apt to refer to that point whatever sounds we may hear,

37

Smell and Taste.

George Gibbs M.D.

18th January 1852

To illustrate

Carpenters Manual. Fig 149. Large drawing
Todd. fig 102 & 105.
Hassall. fig 1. 2. 12. plate 69.
Todd. figs 94. 96. 97. 98. 99. 100. 101 a.
Hassall plates 64. 65. 66.
Boerhaaves Physiology plate 3.

Speech and Taste, completed the lecture before the time.
on Wed. February 4th 1852
Smell & Microscope finished the hour, showing
forms under the Microscope -
on Thurs. February 5th 1852.

Sense of Smell.

Certain bodies possess the property of exciting sensations of a peculiar nature, which cannot be perceived by the organs of taste or touch, but which seem to depend upon the diffusion of the particles of the substance through the surrounding air, in a state of extreme minuteness. As the solubility of a substance in liquid seems a necessary condition of its exciting the sense of Taste, so does its volatility, or tendency to a vaporous state, appear requisite for its having Odorous properties. Most volatile substances are more or less odorous; whilst those which do not readily transform themselves into vapour, usually possess little or no fragrance in the liquid or solid state, but acquire strong odorous properties, as soon as they are converted into vapour, — by the aid of heat, for example. There are some solid substances, which possess very strong odorous properties, without losing weight in any appreciable degree by the diffusion of their particles through the air. This is the case for example with Musk; a grain of which has been kept freely exposed to the air of a room, whose door and windows were constantly open, for a period of 10 years; during which time the air, thus continually changed, was completely impregnated with the odour of musk; and yet, at the end of that time,

the particle was not found to have perceptibly diminished in weight. We can attribute this result to the extreme minuteness of the division of the odorous particles of this substance. There are other odorous solids, such as Camphor, which rapidly lose weight by the loss of particles from their surface, when freely exposed to the air.

The Nose consists, 1, of 2 chief cavities or nasal fossae, separated from one another by a vertical, bony, and cartilaginous septum, and each partially subdivided, by the spongy or turbinated bones, projecting from the outer wall, into 3 passages or meatuses: and, 2, of subordinate chambers, cells, or sinuses, of irregular size, hollowed principally in the ethmoid, sphenoid, frontal, and superior maxillary bones, and communicating by narrow apertures with one or other meatus.

The nasal fossae are lofty and of considerable depth, but much narrowed in lateral extent by the projection of the spongy bones towards the septum, which they almost touch. They open in front by the nostrils; behind they lead, through a vertical slit on each side, the posterior nares or nostrils, into the upper compartment of the pharynx, above the soft palate, into which the food never penetrates, which is strictly a part of the respiratory tract, and which communicates through the Eustachian tubes with the middle ear.

The nostrils have a cartilaginous framework,

which keeps them open, unless forcibly compressed.
This framework consists of 5 principal pieces: One
in the middle, the septal cartilage (a) completing
the septum in front; and 2 on each side, the
lateral and alar cartilages, (b. c.) forming respec
tively the side of the nose below the nasal bones,
and the wing of the nose. The integuments of
the nose are studded with the orifices of seba=
ceous follicles, which are amongst the largest
in the body, and so numerous as to form a thick
continuous layer under the cutis; and immediately within
the nostrils is a growth of strong hairs, or
vibrissae, designed to obstruct the entrance
of injurious substances.

With regard to the interior of the nose its car
tilage are formed of bone, generally thin, compact,
and laminated, everywhere invested with periosteum.
This latter is lined with mucous membrane, the
Schneiderian or pituitary membrane, continuous
with the skin of the face at the nostrils, with the
mucous covering of the eye through the lachrymal
passages, and with that of the pharynx and
middle ear through the posterior nares.

The mucous membrane of the nose varies in its
structure in different regions. Capacious submucous
plexuses of both arteries and veins, the latter being
very tortuous, are situated on the septum and spongy
bones.* These plexuses serve to warm the parts, and to
elevate the temp^{r} of the air on passing to the lungs.
They also serve to explain the tendency to hemorrhage.

* fig 2. pl 69 Hassall

from the nose in cases of general or local plethora.

In the vicinity of the nostrils the mucous membrane exhibits papillae, and a scaly epithelium, like the corresponding parts of the skin. In the sinuses & in all the lower region of the nose, the epithelium is of extreme delicacy, being of the columnar variety, and clothed with cilia.

The proper seat of the sense of smell, a comparatively limited district of the nasal organ, is termed the olfactory region.

This region is situated at the top of the nose, immediately below the cribriform plate of the ethmoid bone, through which the olfactory nerves reach the membrane; and it extends about one third, or one fourth, downwards on the septum, and over the superior and part of the middle spongy bones of the ethmoid. Its limits are distinctly marked by a more or less rich sienna-brown tint of the epithelium, and by a remarkable increase in the thickness of this structure, compared with the ciliated region below; so much so, that it forms an opaque soft pulp upon the surface of the membrane, very different from the delicate, airy transparent film of the sinuses and lower spongy bones.

A good injection of the nasal organ in the foetus both of man and animals, will display a multitude of minute capillary loops upon the surface of the olfactory region, bearing a close resemblance to those of rudimentary papillae. These loops were first pointed out by Mr Jacobi in the foetal

ig, and also in the human foetus at its full term. In the human foetus, after injection, the loops are such as are represented in this figure. (105 Todd Hassall)

The convexity of the loops presents a decided dilatation, being from 2000 to 1500 of an inch wide, while the diameter of the capillary on either side is only about 3000 inch. None of these have as yet been found in the adult. These loops in the olfactory region of the foetus must not be confounded with the loops of the undoubted true papillae, situated just within the nostrils, and which belong to touch.

The first condition essential to the sense of Smell is the existence of a special nerve, the changes in whose condition are perceived as sensations of odour; for no other nerve is capable of these sensations, even though acted on by the same causes. The same substance which excites the sensation of smell in the olfactory nerves, may cause another peculiar sensation through the nerves of taste, and may produce an acrid and burning sensation on the nerves of touch; but the sensation of odour is yet separate & distinct from these, though it may be simultaneously perceived. The second condition of smell is a peculiar condition of the olfactory nerve, or a peculiar change produced in it by the stimulus or odorous substance. It will be here necessary before considering the functions of the nerves, to give you briefly the Anatomy of the nerves of the nose.

The Nerves of the Nose. These are the first pair, and branches of the fifth pair, besides motor filaments from the facial nerve to the external muscles. The first pair has long been considered as the proper nerve of smell, though not without dispute. That it has been right to regarded, however is evident for many reasons. Its limitation to the upper ~~turbin~~ and middle spongy bones, to the roof of the nasal fossae, and to the upper half of the septum, where the mucous membrane exhibits peculiar characters, and smell is principally, if not exclusively exercised; its development in the vertebrate class, proportionate, caeteris paribus, to the acuteness of smell, being largest in animals of keenest scent; the loss of smell, without other effect, consequent on its division; together with the perversion or loss of smell found in many authentic cases in connexion with disease of these nerves or their associated cerebral region: all these facts paint irresistibly to this conclusion.

The olfactory process, or lobe (bij) is a slender prism of fibrous and vesicular nervous matter, terminating in front in a bulb; and it is sunk into the fissure which bounds the supra orbitar convolution on the under surface of the anterior lobe of the cerebrum. It is connected with the inferior surface of the brain by an external and internal root. The former is the longer, and may be traced in the nervous matter forming

the floor of the fissure of Sylvius, and among the
nterior of the locus perforatus, towards the lower
nd outer part of the corpus striatum, near the
nterior commissure of the cerebrum. In the
og and cat, where this process is much larger,
he anterior commissure seems to have a more inte=
mate relation to the olfactory processes. The inter=
al root winds inwards, and is lost in the gray
matter in front of the optic commissure, near the
nterior extremity of the corpus callosum. In front
of the point where the roots join, there is a pro=
ess of gray matter constituting a third or gray
oot, and which is continued forwards as a
ortion of the olfactory process, as far as the
ulb, where it expands.

The bulb of the olfactory process (fig) is
n elongated oval mass of nervous matter which
lies upon the cribriform plate. The white portions
of the olfactory process terminate in its posterior
extremity. It contains a small ventricle, which
in some of the lower animals, is prolonged back=
wards as far as the cerebral ventricles. This
ventricle is lined with a delicate white layer,
but with this exception, the whole olfactory
lobe consists of gray matter. In particular it is
to be observed, that the under portion, which
reposes on the cribriform plate, and sends down
the olfactory filaments, contains no tubular fibres.

The olfactory filaments (figs) are

from 15 to 25 in number, and passing through the apertures of the cribriform plate, may be seen, invested with fibrous sheaths derived from the dura mater, upon the deep or attached surface of the mucous membrane of the olfactory region. They here branch, and sparingly reunite in a plexiform manner, as they descend. They form a considerable part of the entire thickness of the membrane, and differ widely from the ordinary cerebral nerves in structure. They contain no white substance of Schwann, are not divisible into elementary fibrillae, are nucleated, and finely granular in texture, and are invested with a sheath of homogeneous membrane, much resembling the sarcolemma, or, more strictly, that neurilemma existing on the nerves of insects.

(see fig 64 Vol I 3rd Ed.)

No true tubular fibres belong to the olfactory nervous apparatus, except those commissural ones passing between the bulb and certain portions of the cerebrum.

The branches of the 5th pair given to the nose (fig) are derived from its ophthalmic and superior maxillary divisions. The nasal twig of the former, crossing the orbit, passes over the cribriform plate of the ethmoid bone into the nose, in close contact with a portion of the olfactory nerve, and most probably forms some anastomosis with it. Its subsequent course is downwards,

subdividing & supply the mucous membrane and skin in the neighbourhood of the anterior orifices. The pungent sensation preceding sneezing seems to be an affection of this twig, and the flow of tears that accompanies that act is accounted for by the common source of this and of the lachrymal nerve. The nasal branches of Meckel's ganglion enter the nose through the spheno-palatine foramen, or by pores between this and the posterior palatine canal, and then spread over the 3 turbinated bones and the Septum nasi, anastomosing at several points with the olfactory filaments, and with the nasal branch of the ophthalmic (fig). When the fifth nerve is diseased, so that sensation is lost generally in the parts supplied by it, a brush may be introduced into the nostril, and rubbed over the surfaces usually so extremely sensitive, without the slightest discomfort to the patient. Similar effects follow division of the nerve. Hence it may be concluded that the 5th nerve gives common sensibility to the nose, in common with most of the other parts which it supplies.

Conditions of Smell.

In addition to the essential conditions of integrity of the nervous apparatus, and the presence of the requisite stimulus, a healthy ~~act~~ condition of the epithelial investment of the papillae seems necessary for perfect smell.

If the mucous surface is dry, or if it is in the irritable state, attended with watery discharge, induced by cold, smell is impaired or lost. This is explained by considering the manner in which the nerves are ordinarily brought under the influence of the stimulus. As in taste, a solution of the stimulus in the surface of the membrane is requisite in order that the odorous substance may actually reach the nerve. Insoluble substances cannot be smelt. Hence, whether the membrane be too dry, or an inordinate excretion of fluid be going on from its surface, the necessary penetration of the stimulus to the nerves is alike interfered with.

Two important reasons for the situation of the organ of smell, so high up in the nose, are that it is thereby screened from the contact of air either too cold or too dry. The projection of folded membranes, break the force of the current, and the plexuses of blood warm it, and impart the necessary degree of moisture.

Animals do not all equally perceive the same odours. The Carnivora accurately smell the peculiarities of animal matter, and of tracking other animals by the scent; but have apparently no sensibility to the odours of plants & flowers. Herbivorous animals are peculiarly sensitive to the latter, and less so to animal odours. Man is far inferior to many animals of both classes

respect of the keenness of smell; but his share in the process is more uniform and extended.

In a man who was constantly conscious of a bad odour, the arachnoid was found after death by M. M. Cullerier & Maignault, to be beset with deposits of bone; and scrofulous cysts, suppurating, in middle of the cerebral hemispheres. Dubois was acquainted with a man who, ever after a fall from his horse, which occurred several years before his death, believed he smelt a bad odour.

My own 2 cases of Thompson & Fraser.

Sense of Taste.

The conditions for the perception of taste are:—

1. the presence of a nerve with special endowments.
2. the irritation of this nerve by the sapid matters.
3. the solution of these matters in the secretions of the organ of taste.

Of the Nerves of taste. Taste has been shewn to exist independently in parts supplied, on the one hand solely by the glosso-pharyngeal nerves, on the other solely by the lingual branches of the fifth pair, it follows, as a direct consequence, that these nerves must respectively participate in the sense; and there is reason besides to attribute a share to the palatal branches of the fifth.

Amid many conflicting statements on this disputed point, the weight of evidence derived from other sources seems to be much in favour of the foregoing conclusion; viz, that both nerves possess the special function of ~~sense~~ taste.

The origin and connexions of these nerves have been already described in my former lectures.

The mode of action of the substances which excite taste probably consists in the production of a change in the internal condition of the gustatory nerves, and, according to the difference of the substances, an infinite variety of changes of condition, and consequently of tastes, may be induced. It is not, however, necessary for the manifestation of taste that sapid substances in solution should be brought into contact with its nerves. For the nerves of taste, like the nerves of other special senses, may have their peculiar properties excited by various other kinds of irritation, such as electricity and other mechanical impressions. Thus Henle observed that a small current of air directed upon the tongue gives rise to a cool saline taste, like that of saltpetre; and Dr Baly has shewn that a distinct sensation of taste, similar to that caused by electricity, may be produced by a smart tap applied to the papillae of the tongue. Moreover the mechanical irritation of the fauces and palate produces the sensation of nausea, which is probably only a modification of taste.

The matter to be tasted must either be in solution
- be soluble in the moisture covering the tongue;
since insoluble substances are usually tasteless,
and produce merely sensations of touch. Moreover
for a perfect action of a sapid, as of an odorous
substance, it is necessary that the sentient sur=
face should be moist. Hence when the tongue
and fauces are dry, sapid substances, even in
solution, are with difficulty tasted.

The principal, but not exclusive, seat of the
sense of taste is the fauces and tongue. The
tongue is a muscular organ whose use in relation
to mastication and deglutition has already been
considered in my 2nd lecture on digestion. The
free surface is covered with structures analagous
to those of the skin, namely, a cutis or corium,
on which are placed papillae, and which,
together with them, is invested by epithelium.

The cutis is thinner and less dense than that
of the skin, but is constructed of similar tis=
sue, serves as a ground-work for the ram=
ification of the abundant vessels blood and
nerves which the tongue receives, and affords
insertion to the extremities of the muscular fibers
of which the chief substance of the organ is com=
posed.

The papillae of the tongue are thickly set
over its whole upper surface, giving to it its char=
acteristic roughness. Their greater prominence

than those of the skin is due to their interspaces not being filled up with epithelium as the interspaces of the papillae of the skin are.

The papillae of the tongue present several diversities of form; but 3 principal varieties, differing both in real and general characters, may usually be distinguished.

1st Circumvallate or calyciform papillae, 8 or 10 in number, situate in 2 V-shaped lines at the base of the organ. These are circular elevations from 1/20 to 1/12 of an inch wide, each with a central depression, and surrounded by a circular fissure, at the outside of which again is a slightly elevated ring; both the central elevation and the ring being formed of close-set simple papillae. (fig 96 Todd) Hassall

2nd. Fungiform papillae, scattered chiefly over the sides and tip, and sparingly over the middle of the dorsum, of the tongue; their name is derived from their being usually narrower at their base than their summit. They also consist of groups of simple papillae, each of which contains in its interior a loop of capillary blood-vessels & a nerve fibre. (fig 98 Todd & Hassall)

3rd. Conical or filiform papillae: these, which are the most abundant, are scattered over the whole surface but especially over the middle of the dorsum. Their name denotes their shape. (in various figs in Todd) Hassall

The epithelium of the tongue is of the tessellated kind, like that of the epidermis. It covers every part of the surface, but over the fungiform papillae forms a thinner layer than elsewhere, so that these papillae

stand out more prominently than the rest. The epithelium covering the conical papillae has been shewn by Todd & Bowman to have a singular arrangement; being extremely dense and thick, and projecting from their sides and summits in the form of long, stiff, hair-like processes. Many of these processes bear a close resemblance in structure to hairs, and some actually contain minute hair-tubes. (Todd fig°)

Each of the 3 varieties of papillae just described have been commonly regarded as simple processes, like the papillae of the skin, but Todd & Bowman have shewn that the surface of each is studded by minute conical processes of mucous membrane which thus form secondary papillae. These secondary papillae also occur over most other parts of the tongue, not occupied by the compound papillae. They are commonly buried beneath the epithelium; hence have been hitherto overlooked. (Figs 101 in Todd)

Such is an outline, of the structure of the sensitive surface of the tongue. But the tongue is not the only seat of the sense of taste, for the results of experiments as well as ordinary experience shew that the soft palate and its arches, the uvula, tonsils, and probably the upper part of the pharynx are endowed with taste. These parts, together with the base and posterior part of the tongue, are supplied with branches of the glosso-pharyngeal nerve, and evidence has been already adduced

that the sense of taste is conferred upon them by this nerve.

In most, though not in all, persons the anterior part of the tongue, especially the edges & tip, are supplied with taste. The middle of the dorsum is only feebly endowed with this sense, probably because of the density and thickness of the epithelium covering the filiform papillae of this part of the tongue, which will prevent the sapid substances from penetrating to the sensitive parts. The use of these papillae is, therefore, probably less for taste than for mechanical purposes in the act of mastication. The gustatory property of the anterior part of the tongue is due, as already stated to the lingual branches of the fifth nerves.

Besides the sense of taste, the tongue, by means of its papillae, is endowed, especially at its sides and tip, with a very delicate and accurate sense of touch*, which renders it sensible of the impressions of heat and cold, pain, and mechanical pressure, and consequently of the form of surfaces. The tongue may lose its common sensibility, and still retain the sense of taste, and vice versâ. This fact renders it probable, that although the senses of taste and of touch may be exercised by the same papillae supplied by the same nerves, yet the nervous conductors for these 2 different sensations are distinct, just as the nerves for smell and common sensibility in the nostrils are distinct;

* see Todd. fig 101. C.

and it is quite conceivable that the same nervous trunk may contain fibres differing essentially in their specific properties. Facts already detailed seem to prove that the lingual branch of the 5th nerve is the seat of sensations of taste in the anterior part of the tongue: and it is also certain, from the marked manifestations of pain to which its division in animals gives rise, that it is likewise a nerve of common sensibility. The glosso-pharyngeal also seems to contain fibres both of common sensation and of the special sense of taste.

Much of the perfection of the sense of taste is often due to the sapid substances being also odorous, and exciting the simultaneous action of the sense of smell. This is shewn by the imperfection of the taste of such substances when their action on the olfactory nerves is prevented by closing the nostrils. Many fine wines lose much of their apparent excellence if the nostrils are held close while they are drunk.

Very distinct sensations of taste are frequently left after the substances which excited them have ceased to act on the nerve; and such sensations often endure for a long time, and modify the taste of other substances applied to the tongue afterwards. Thus the taste of sweet substances spoils the flavour of wine, the taste of cheese improves it.

Frequent and continued repetition of the same taste
renders the perception of it less & less distinct,
in the same way that a colour becomes more
and more dull and indistinct, the longer the
eye is fixed upon it. Thus after frequently
tasting first one and then the other of 2
kinds of wine, it becomes impossible to
discriminate between them.

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Anatomy of the Eye.

Geo. D. Gibb M.D

20th January 1852

To illustrate

All the plates in Todd
Demours on the Eye. pl X &c.
Loose plates of the Eye.
Hassall plates. 67 & 68.

I only got as far as page 13. Time was occupied by the illustrations & descriptions.

Anatomy of the Eye.

It would appear that an animal may be sensible of light without possessing an organ of vision, as is instanced in the hydra, which moves to the light side of a vessel in which it is kept. And light is as essential to plants as it is to animals, in the performance of their functions. Among the lower invertebrata, the eyes, or ocelli, consist only of a nervous point, shielded with a minute quantity of colouring matter. In the higher animals we find transparent media and lenses for the refraction of light, and the production of a more precise image; of an apparatus for the regulation of the quantity of light admitted to the retina; and of other appendages for protection and movement.

The position of the human eye at the upper part of the face and directed forwards, while it gives to the countenance its most important element of beauty, adds greatly to the utility of the organ by increasing the visual range. For protection in this exposed situation, it is sunk deeply in a cushion of fat, with a bony cavity, the orbit, the prominent borders of which are well adapted to receive the force of blows directed towards the eyes. It is furnished with muscles capable of moving it towards any side, and of protruding or sinking it. It is also provided with moveable lids to guard its exposed surface from mechanical injury, and its nerve from the effects

of excessive light: and with a lachrymal apparatus by which the front of it is continually irrigated with a bland fluid.

In the globe of the eye itself we recognise, as the most essential constituents, the expansion of the optic nerve, called the retina; and in front of this, the transparent refracting media which, as a whole, transmit the light so as to bring its rays to a focus upon the nervous sheet. The curved form of the retina, and the rounded figure of the eye thence derived, are perfectly adapted to the curvatures of the refracting media: so that if the nervous lamina had assumed any other shape, it would have been more or less apt to focus, and vision consequently have been indistinct.

To maintain the figure of the retina, and to protect a part of so much delicacy, in which the slightest change of form would be attended with injury to the function, the whole is encased in a dense tunic of great strength, termed the sclerotica (σκληρός, durus), which is opaque, except in front, where it is modified in structure, becomes perfectly transparent to allow the light to enter, and is known as the cornea. Between the sclerotica and the retina is interposed a layer of dark pigment, contained in a delicate membrane termed the choroid. In front of the retina are the transparent media. One of these (the vitreous body or humor) is contained immediately

within the cup which the retina forms, and appears specially constructed to give it that necessary cup at inside, which the sclerotica furnishes on the outside. The vitreous body occupies 4/5 of the whole globe. Imbedded in its anterior part is a double convex lens (the crystalline lens or body,) which comes nearly up to the cornea; leaving, however, a small cavity containing a watery fluid, the aqueous humor, between itself and that transparent part of the external case. Across this cavity, and dividing it into an anterior and posterior chamber, hangs a vertical curtain-like process of the choroid, called the iris, perforated in the centre by an aperture, the pupil, for the admission of light to the interior, and contractile under the influence of light on the retina, in order that it may regulate the amount of light entering the organ. The perfect fluidity of the aqueous humor is a provision to allow of the expansion and contraction of the pupil, & of the movements of the lens itself towards or from the cornea.

The human eye would be nearly globular were it not that the anterior portion, formed by the cornea is a part of a smaller sphere than the rest, & is therefore slightly protuberant. Hence the antero posterior axis of the eye is longer than the transverse, in the proportion of 20 to 19.

A more detailed description of the several structures composing the ball of the eye will not be necessary, proceeding now without interruption.

The sclerotic Coat consists of white fibrous tissue, in which, however, the ultimate filaments are more distinct, and less many than in ordinary specimens. These form numerous layers, crossing one another chiefly at right angles, and thus constitute a membrane capable of resisting distension, and of retaining its figure under pressure. It has a white glistening aspect, especially in front, where it receives the insertion of the tendons of the 4 recti muscles, and being visible, is familiarly known as the "white of the eye." The sclerotic is thickest behind, and becomes gradually thinner in front, till nearly in contact with the cornea, where it increases in strength a little. see # page 16 of Todd

The optic nerve comes through the sclerotic behind at a distance of about its own breadth, or nearly 1/8th of an inch, on the inner side of the axis of the eye, by which is meant the axis of the dioptric media. This nerve contains a considerable quantity of fibrous tissue separating and supporting its fasciculi, and as it traverses the sclerotic this tissue becomes continuous with the borders of the aperture, so that the aperture itself may be said to be cribriform; the nerve passing through a number of distinct canals of fibrous tissue, before it reaches the inner surface of the sclerotic. The nerve as it pierces the sclerotic, contracts, and lies in a smaller compass, so that the entire aperture

is somewhat funnel shaped, and wider behind than front; and though the nerve is moveable on its entrance into the sclerotic aperture, it is always fixed firmly at the inner surface of that aperture, where the retina commences. ~~The aperture in the sclerotic for the cornea is circular~~

The aperture in the sclerotic in front, for the cornea, is circular, and usually about $\frac{7}{16}$ ths of an inch in transverse diameter, and rather less vertically, though in some individuals altogether smaller. Between the point of entrance of the optic nerve, and the attachments of the recti muscles, are several minute apertures for the transmission of vessels and nerves to the interior. The nutrition of the sclerotic itself is provided for by small vessels ramifying on its surface, and sparingly continued into its substance. Its own proper vascularity does not seem to be greater than that of other fibrous structures.

Of the Cornea. The size and shape of this part of the case of the eye have been given. It is spherical rather than spheroidal, and its posterior surface is of parallel curvature with the anterior; so that it does not appear to be a meniscus lens, thicker in the middle, as some authors have described.

The cornea when its concavity is filled up with aqueous humour is a powerful conveyer of the rays of light towards the iris, & thro the pupil to the lens. Viewed from within, its circumference is exactly circular; but on the outside it generally appears wider

transversely, from the sclerotic, which overlaps it on
all sides, encroaching upon it rather more above
and below. The cornea & sclerotic are firmly connec
ted by continuity of texture, and cannot be disunited
even by maceration. The cornea is possessed of
great toughness, & will even resist a force capable
of rupturing the sclerotic.

The cornea though beautifully transparent, is
nevertheless an elaborate structure. It is in fact com
posed of 5 coats or layers, clearly distinguishable from
one another. These are from before backwards:—

1 Conjunctival layer of epithelium (fig 111 Todd
2 Anterior elastic lamina
3 Cornea proper
4 Posterior elastic lamina
5 epithelium of aqueous humour, or posterior epithelium.

On the Cornea proper or Lamellated cornea, the thick
ness and strength of the cornea mainly depend.
It is a peculiar modification of the white fibrous
tissue, continuous with that of the sclerotic.
At their line of junction (fig 109 Todd.)
the fibres, which in the sclerotic have been densely
interlaced in various directions, and mingled with
elastic fibrous tissue, flatten out into a membra
nous form, so as to follow in the main the cur=
vatures of the surfaces of the cornea, and to con=
stitute a series of more than 60 lamellae, intimately
united to one another by very numerous processes
of similar structure, passing from one to the other
and making it impossible to trace any one lamella
over even a small portion of the cornea.

the resulting areolae, which in the sclerotic are irregular and on all sides open, are connected in the cornea into tubular spaces, which have a very singular arrangement, hitherto undescribed. They lie in superposed planes, the contiguous ones of the same plane being for the most part parallel, but crossing those of the neighbouring planes at an angle, and seldom communicating with them. (fig 110 Todd —)

The arrangement and size of these tubes can be shewn by driving mercury, or coloured size, or air, into a small puncture made in the cornea. They may also be shewn under a high power by maceration a thin section of a dried cornea, and opening it out by needles. The tissue forming the parietes of these tubes is membranous rather than fibrous, though with the best glasses a fibrous striation may be frequently seen, both in the laminae separating the different series of tubes, and in that dividing those of the same layer from each other. By acetic acid, also, the structure swells, and displays corpuscles resembling those apparent in the white fibrous tissue. Such is the lamellar structure of the cornea, which makes it so much easier to thrust an instrument horizontally than vertically into its substance. The tubes or elongated spaces of which we have spoken, are not distended with any fluid, but are merely maintained in the same way as the areolae of ordinary areolar tissue. A perfectly fresh and transparent cornea is rendered opaque by pressure, but

but it regains its brilliance on the removal of the compressing force. This has been supposed due to the expulsion of fluid from between its laminae but it is not the case.

Of the anterior elastic lamina. This is a transparent homogeneous lamina, co-extensive with the cornea, and forming the anterior boundary of the cornea proper. Its office seems to be that of maintaining the exact curvature of the front of the cornea, by means of filamentous cords, which pass from its posterior surface and edge into the substance of the cornea proper and sclerotic. (fig III b. Todd)

The conjunctival epithelium of the cornea may be always obtained from a fresh eye, by gently scraping its surface. It consists of 3 or 4 layers of superposed particles, inclining to the columnar form where they rest on the anterior elastic lamina, and becoming imbricated scales on the surface.

It is this epithelium which [fig III a. Todd lodges particles of dust, &c, and are easily detached. Vessels shooting in the cornea in disease lie under it, and small ulcers are formed by its destruction.

The Posterior elastic lamina of the cornea (III d) is a very thin membrane, with no visible structure. It adheres but slightly to the cornea proper, and when peeled off has a tendency to curl.

Of the epithelium of the aqueous humor. The elastic lamina is itself lined by an exceedingly delicate epithelium which exactly resembles that existing on serous membranes (fig III e. o. p also p129 vol 1 Todd)

this epithelium probably secrets the aqueous humour, but it is probably limited to the cornea.

Of the Choroid. On turning aside the sclerotic and cornea (fig 112) the choroid with its process the iris, is exposed. The choroid is of course perforated behind by the optic nerve, and there adheres pretty firmly to the sclerotic. The choroid on coming up to the cornea, gives off its process the iris, and it adheres intimately to the sclerotic by a very narrow ring of white tissue — the ciliary ligament.

The choroid contains some fibrous tissue, resembling that of the sclerotic; but it is composed principally of blood vessels and pigment cells. It is usually described as having 3 layers, an arterial a venous, and a membrana pigmenti, the internal, but this is not strictly correct. It is in fact a thin lamina of capillaries, in a close network, a plexus formed of arteries & veins. The arteries are internal on the surface of the choroid, and known as the tunica Ruyschiana. (Has. pl 67. fig 4)

The veins come to it & leave it at very numerous points, but on its outer surface, they are large and numerous, and disposed in beautiful curves, converging to 4 or 5 trunks, before quitting the choroid, and styled the venae vorticosae. (fig 112. ee. Todd - Has. pl 68 fig 1 & 2*). The arteries run between these but less regularly.

On the inner surface of the capillary network, and between it and the arteries & veins, as well as

* Demonus also, 1 & 2 Coll plate 10. also 2 plate 13.

among the veins themselves, there is a great abundance of colouring matter which deeply tinges the whole thickness of the membrane. The pigment-cells in the substance of the choroid (fig 114. B. Todd) are extremely irregular in shape, and lie in various directions amongst the other elementary tissues. They are so loaded with pigment that their nuclei are often obscured by it. The pigmentary matter within these cells is of a sepia colour, and occurs in the form of oblong or oval grains, less than $\frac{1}{10000}$ of an inch long (fig 114. b). These grains exhibit molecular motion when removed from the cells, and sometimes even within the cells. The ash consists of com: salt, lime, phos lime & oxide iron.

In albinos the colouring matter is deficient not only in the eyes, but in other organs in which it usually exists. The eyes have consequently a pink appearance, derived chiefly from the blood in the choroid and iris.

Of the Choroidal epithelium. This is the 3rd or inner coat of the choroid of most authors. It is situated on the inner surface of the choroid, within the capillary network, and adhering slightly to it, and consists of a single layer of nucleated particles, of a pentagonal or hexagonal shape, filled with pigment. This was described by Mr Wharton Jones, who termed it the Membrane of the black pigment. This epithelium exists without pigment in front of tapetum lucidum of animals. fig 114. A

The retina ceases at a line (ora serrata) about 1/8 th of an inch behind the margin of the cornea. In front of this line, and as far as the iris, the choroid is known as the ciliary body; being modified to form the ciliary processes; and it is covered on its outer surface by a semi-transparent tissue, the ciliary muscle, at the anterior edge of which is a more opaque white ring, the ciliary ligament.

The ciliary processes of the choroid project as folds, or plaitings, into the vitreous humor and are there lodged in corresponding folds, the ciliary processes of the vitreous body. They are seen from within to commence at the anterior border of the retina, or ora serrata, as mere streaks, converging towards the lens; and it is only when advanced more than halfway to that body that they become projected in about 60 or 70 plaits, with subordinate ones between. These terminate by small free extremities, which slightly overlap in front the border of the lens, without touching it, being united to it through the medium of a delicate layer of the hyaloid membrane of the vitreous humour. These folds take form hold of the vitreous humour in its front part, all round the lens. Their texture is very vascular (113.b.) and filled with irregular pigment cells, and on their inner surface is a tough colourless lamina, composed of ill defined nucleated cells,

by means of which they are connected to the hyaloid membrane. The ciliary processes by their anterior surface contribute to form the posterior wall and side of the posterior chamber, and are continuous with the back of the iris. They are then free & washed by the aqueous humor.

The <u>iris</u> may rightly be regarded as a process of the choroid; it is continuous with it, although of a modified structure. It forms a vertical curtain stretched in the aqueous humor before the lens, & perforated for the transmission of light. It is attached all round at the junction of the sclerotic and cornea, with the posterior elastic lamina. This lamina near its border begins to send off from its anterior surface, or that towards the laminated cornea, a network of yellow elastic fibres, which stretch towards the border, becoming thicker as they advance, until at length the entire thickness of the lamina is expended by being converted into them. ~~The~~ (fig 115 Todd —)

The iris is continuous behind, near its border, with the ciliary processes, and is only free in the inner half of its extent, near the pupil, where it is covered with a dense layer of pigment and marked by converging striae. This posterior surface is termed <u>uvea</u>.

The anterior surface of the iris has a brilliant lustre, and is marked by lines taking a more or less

direct course towards the pupil. The varieties in colour in the eyes of different animals and individuals depend almost solely on the colour of the front of the iris, which itself resides chiefly in pigment cells.

The iris is contractile, and the anatomical characters of its principal tissue so nearly resemble those of unstriped muscle, that it may be considered as a variety of that tissue. Its fibres are loaded with nuclei, which are rather rounder than those of unstriped muscle, & more loosely attached.

The iris is so vascular that some anatomists have considered it erectile. But its vessels are slender & delicate & resemble those of unstriped muscle. They are derived from the 2 long ciliary arteries.

On the anterior surface near the pupil, a vascular circle marks the line from which in the foetus the membrana pupillaris stretched across in front of the pupil.

The grayish structure coating the choroid for about 1/8 of an inch behind the cornea, presents at its anterior edge a more white & opaque circle the ciliary ligament, which seems to be chiefly of a fibrous character, & to connect the border of the iris firmly to the sclerotic.

The ciliary muscle is that grayish, semi-transparent structure behind the ciliary ligament and covering the outside of the ciliary body. It has been described as muscular —

Within the choroid is the retina, which shall be described as a distinct structure from the optic nerve.

The retina is the sheet of nervous matter which receives the images of external objects thrown upon it by the transparent media, & it is accordingly placed immediately behind the vitreous humor the deepest of the media. It commences at the foramen in the sclerotic & choroid by which the optic nerve enters the eye, & terminates by a finely jagged border (the ora serrata) at the hinder border of the striated part of the ciliary body. It is thicker behind than before.

It is described as possessing 3 layers:—

External — or Jacobs membrane
Middle — Nervous layer, expan[sion] of optic nerve
Internal — Vascular layer —

The middle or nervous layer, consists of a fibrous, & a vesicular gray layer. The fibrous gray layer is of a fibrous character, radiating from the end of the optic nerve, and apparently consisting of tubular fibres of that nerve deprived of their white substance; that is being no longer tubular and white, but solid and gray, & united together more or less into a membrane. This layer is united to the hyaloid membrane, containing the vitreous humor, by a layer of nucleated cells almost perfectly transparent, & sometimes difficult to discover in consequence.

The vesicular gray layer is on the outer surface of the fibrous layer, & so intimately blended with it, that it might almost seem as if the fibres successively terminated in it. This layer

is thicker behind & thinner in front. The Internal or vascular layer is formed of bloodvessels thickly distributed but solely to the nervous layer just described, in ~~the~~ an arborescent capillary network in the substance of the vesicular stratum.

(Hassall pl 67, figure 2)

Behind or external to the nervous layer is the granular layer, consisting of a close aggregation of small granules, which refract the light powerfully — This may be included as belonging to the middle layer of the 3rd tunic of the eye.

The External layer, is the membrana Jacobi. It consists of club-shaped rods, placed uprightly the thin end ~~xxx~~ inwards, the thick outwards; and it is very easily detached from the rest of the retina, when the choroid is removed, so as to float as delicate shreds, visible to the naked eye, in the water in which the eye is immersed. (Fig 118 Todd). The rods have a tendency to separate from one another when placed in water, and the club shaped extremities are then often seen to be formed by a sudden bending back of the stem like a crook, which may be more or less opened out. (Fig 117. M. Todd)

It has been before stated that the optic nerve pieces the sclerotic and joins the retina about 1/8 of an inch on the inner side of the axis of the eye. Precisely in this axis, the retina is of a decidely yellow colour in a roundish spot of about 1/24 of an inch diameter, called after its discoverer, the yellow spot of Soemmering.

Demours 2.4.5 of coloured Plate 9

this spot exists only in man and the monkey or=
ming mammalia, but an analogous part has been
found by Dr Knox in reptiles. It is a mound
or projection of the retina towards the vitreous
humor, with a minute aperture in the summit.
The fibrous expansion of the optic nerve cannot
betraced quite up to the spot itself. The use
of this yellow spot is unknown.

The vitreous body, lying in the concavity of
of the retina, and filling all but about the
anterior fifth of the globe, has when entire,
the consistence of soft jelly. It consists of an
exceedingly fine and close, but perfectly trans=
parent web of fibrous tissue, the meshes of
which are exceedingly small, and contain
an aqueous fluid. Then is a cavity in the vit=
reous body, all round the rim of the lens, ex=
tending under the circle of the ciliary processes,
and termed the canal of Petit. (Fig 120 & 116 Todd)

The Crystalline, is a double convex lens, but
its surfaces are of unequal curvature, the posterior
being the more convex. The lens alters its shape
with age; being in the foetus more spherical, more
flattened in childhood, and still more so in
advanced age. (Fig 121). In infancy it projects
into the aqueous humor so as to touch the iris,
but in old age there is a space intervening. The
lens also varies in consistence with age; being
very soft at an early period, very firm in declining
years. It is divided into Capsule and body.

The anterior wall of the capsule is nearly 4 times thicker than the posterior; it is perfectly closed and cannot allow of the passage of either vessel or nerve to its interior.

The body of the lens is constructed of fibres placed one above another, and united side by side in laminae, of which many hundreds must exist. 3 lines are visible on the surface in Mammalia, which divide it into 3 equal parts. (Figs 123. & 124.)

The superficies of the lens, by which it comes into contact with the capsule, consists of a layer of extremely transparent nucleated cells. Fig 122. a. After death they become loaded with water, which is the aqua Morgagni. The average thickness of the fibres of the lens in man, is $\frac{1}{8000}$ of inch.

The lens during development, has copious supply of blood to its capsule from 2 sources; arterial centralis retinae, and the anastomoses of its branches with the ciliary processes. The lens consists chiefly of albumen, becomes hard & opaque by boiling. The aqueous humor, is nearly pure water. It fills up the space between the cornea & lens — a space divided into 2 cavities by the membrana pupillaris in the foetus, and still partially divided by the iris into an anterior & posterior chamber communicating through the pupil. It is said the membrane of aqueous humor, is nervous, but it is not a shut sac, nor has any epithelium of serous membrane been found.

39

Physiology of the Eye.

Geo. Gibbs M.D.

28th January 1852

To illustrate

Todd figs 125 & 126
Lenticular Ganglion
draw diagram fig 41 Kirkes
— do — " 42 do
— do — " 44 do
drawing of Chiasma from Quain.

Some few pages over, in consequence of yesterday being long - but do not shorten either -

Physiology of the Eye.

The second pair of nerves is devoted to the sense of sight, and on that account has received the name of optic nerves.

The optic nerves form a most extensive connexion with the brain through the optic tracts. The optic tracts are 2 flattened bands of nervous matter, which proceed from the posterior & superior surface of the mesocephale (the region of the quadrigeminal ~~tubercles~~ tubercles) forwards along the inferior surface of ~~the mesocephale~~ each crus cerebri, and after passing in a curved course (concave inwards) along the base of the brain, unite in front of the tuber cinereum and mamillary bodies and form a new intimate junction which is called the chiasma or commissure of the optic nerves. Fig 125 Todd

From this chiasma the optic nerves spring and diverge as they pass forwards into the orbits through the optic foramina. This point may be looked upon therefore as their origin.

The optic tracts are connected with the optic thalami chiefly through the geniculate bodies. Each tract ~~divides~~ adheres to the outer side of its corresponding thalamus for some distance, but whether any fibres sink into it is not determined. The chiasma results from the junction of

the optic tracts in front of, and inferior to, the tuber cinereum. The fibres which form the inner margin of each tract (fig 126 Todd fr.) are continued across from one side of the brain to the other, and form no connexion with the optic nerves, and exist where those nerves do not exist as in the male. These fibres may be regarded as commissural between the thalami of opposite sides. The remaining fibres of the tracts go to form the optic nerves; the central ones pass into the nerve of the opposite side, decussating the similar fibres of the other tract; and the outermost fibres, much fewer in number than the central ones, pass to the optic nerve of the same side. same fejunn.

The optic nerves appear also to be connected by fibres, forming the anterior border of the chiasma, and which may be regarded as commissural between the 2 retinae (a fig 126).

From the quadrigeminal tubercles to the chiasma, nerve tubes, mostly of large size, are visible by the microscope in the tracts. In the chiasma and optic nerves, the fibres, although very variable in size, are so closely connected together that it is exceedingly difficult to separate them. Other nerves distributed to the eye are derived from the ophthalmic division of the 5th, from the third pair, and from the sympathetic. It is remarkable

however that all these nerves, with 2 exceptions between their origin and their distribution in the globe of the eye, meet in a small ganglion situated on the outer side of the optic nerve, called the ophthalmic or lenticular ganglion. This body is usually considered a portion of the cephalic division of the sympathetic; it is connected* by a long branch which [* with the superior cervical ganglion] descends from the carotid plexus along the carotid artery, and enters the orbit.

(show the lenticular ganglion, figure of)

Of the Phenomena of Vision.

The essential constituents of the optical apparatus of the eye are: a nervous expansion to receive and transmit to the brain the impressions of light; certain refracting media for the purpose of so disposing of the rays of light traversing them as to throw a correct image of an external body on the retina; and a contractile diaphragm with a central aperture for regulating the quantity of light admitted into the eye. All these have been considered in my previous lecture.

With the help of this diagram, (show it. fig 41 Kirkes) representing a vertical section of the eye from before backwards, the mode in which, by means of the refracting media of the eye, an image of an object of sight is thrown on the retina may be rendered intelligible. The rays of the cones of light emitted by the points A B, and every other point of an

object placed before the eye, are first refracted, that is, are bent towards the axis of the cone, by the cornea C C, and the aqueous humour contained between it and the lens. The rays of each cone are again refracted and bent still more towards its central ray or axis by the anterior surface of the lens E E; and again as they pass out through its posterior surface into the less dense medium of the vitreous humour. For a lens has the power of refracting, and causing the convergence of the rays of a cone of light, not only on their entrance from a rarer medium into its anterior convex surface, but also at their exit, from its posterior convex surface into the rarer medium.

In this manner the rays of the cones of light issuing from the points A and B are again collected to points at a and b; and, if the retina F be situated at a and b, perfect, though reversed, images of the points A and B will be perceived: but if the retina be not at a and b, but either before or behind that situation, — for instance at H or G, — circular luminous spots c and f, or e and g, instead of points, will be seen; for at H the rays have not yet met, and at G they have already intersected each other, and are again diverging. The retina must therefore be situated at the proper focal distance from the lens, otherwise a defined image will not be formed; or in

ther words, the rays emitted by a given point
the object will not be collected into a corres
anding point or focus upon the retina.

The means by which distinct and correct images
objects are formed in the retina, in the various
conditions in which the eye is placed in relation
external objects, may be separately considered
under the following heads:—

1. the means for preventing indistinctness from aberration.
2. the means for preventing it when objects are
viewed at different distances.
3. the means by which the inverted image of an ob=
ject on the retina is perceived as in its
right position by the mind.

1. Since the retina is concave, and from its
centre towards its margins gradually approaches
the lens, it follows that the images of objects
situated at the sides cannot be so distinct
as those of objects nearer to the middle of the
field of vision, and of which the images are
formed at a distance behind the lens exactly
corresponding to the situation of the retina.
Moreover the rays of a cone of light from an object
situated at the side of the field of vision do
not meet all in the same point, owing to their
unequal refraction; for the refraction of the
rays which pass through the circumference of
a lens is greater than that of those traver=
sing its central portion. The concurrence of
these 2 circumstances would cause indistinctness

vision, unless corrected by some contrivance. Such correction is effected, in both cases, by the iris, which forms a kind of annular diaphragm to cover the circumference of the lens, and to prevent the rays from passing through any part of the lens but its centre, which corresponds to the pupil.

The image of an object will be most defined and distinct when the pupil is narrow, the object at the proper distance for vision, and the light abundant; so that, while a sufficient number of rays are admitted, the narrowness of the pupil may prevent the production of indistinctness of the image by this spherical aberration or unequal refraction just mentioned. But even the image formed by the rays passing through the circumference of the lens, when the pupil is much dilated, as in the dark, or in a feeble light, may, under certain circumstances, be well defined; the image formed by the central rays being then indistinct or invisible, in consequence of the retina not receiving these rays where they are concentrated to a focus.

Distinctness of vision is further secured by the inner surface of the choroid, immediately external to the retina itself, as well as the posterior surface of the iris and the ciliary processes being coated with black pigment, which absorbs any rays of light that may be reflected within the eye, and prevents their being thrown again upon the retina so as to

interfere with the images there formed. The pigment of the Choroid is especially important in this respect; for the retina is very transparent, and if the surface behind it were not of a dark colour, but capable reflecting the light, the luminous rays which had already acted on the retina would be reflected back again through it, and would fall upon other parts of the same membrane, producing both dazzling from excessive light, and indistinctness of the images.

In the passage of light through an ordinary convex lens, decomposition of each ray into its elementary coloured parts commonly ensues and a coloured margin appears around the image, owing to the unequal refraction which the elementary colours undergo. In optical instruments this, which is termed chromatic abberration, is corrected by the use of 2 or more lenses, differing in shape and density, the second of which continues or increases the refraction of the rays produced by the first, but by recombining the individual parts of each ray into its original white light, corrects any chromatic aberration which may have resulted from the first. It is probable that the unequal refractive power of the transparent media in front of the retina, may be the means by which the eye is enabled to guard against the effect of chromatic aberration.

The human eye is achromatic however, only so long as the image is received at its focal distance upon the retina, or so long as the eye adapts itself to the different distances of sight. If either of these conditions be interfered with, more or less distinct appearance of colours is produced.

2. The distinctness of the image formed upon the retina is mainly dependant upon the rays emitted by each luminous ~~point~~ point of the object being brought to a perfect focus upon the retina. If this focus occurs at a point either in front of, or behind the retina, indistinctness of vision ensues, with the production of a halo. The focal distance, i.e. the distance of the point at which the luminous rays from a lens are collected, besides being regulated by the degree of convexity and density of the lens, varies with the distance of the object from the lens being greater as this is shorter and vice versâ. Hence, since objects placed at various distances from the eye can, within a certain range, different in different persons, be seen with almost equal distinctness, there must be some provision by which the eye is enabled to adapt itself; so that whatever length the focal distance may be, the focal point may always fall exactly upon the retina.

~~The power~~ This power of adaptation of the eye
& vision at different distances has received
the most varied explanations. It is obvious
that the effect might be produced in either of
2 ways; viz, by altering the convexity or den=
sity, and thus the refracting power, either of
the cornea or lens; or by changing the position
either of the retina or of the lens, so that whe
ther the object viewed is near or distant, and
the focal distance thus increased or diminished,
the focal point to which the rays are converged
by the lens, may always be at the place occupied
by the retina. The amount of either of these
changes required in even the widest range of
vision, is extremely small. For, from the refrac
tive powers of the media of the eye it has been
calculated by Olbers that the difference between
the focal distances of the images of an object
at such distance that the rays are parallel,
and of one at the distance of 4 inches, is only
about 0.143 of an inch.

Both of the above conditions, as well as sev
eral others have been supposed sufficient alone
to account for the power of adaptation of the eye.
Thus, by Sir E. Home and others, it has been
attributed exclusively to a change in the convexity
of the cornea produced by the muscles of the eyeball.
By others the power of adaptation has been ascribed
to alterations in the form of the whole globe of

the eye, by the action of the muscles.

The movements of the iris have been considered the means of adaptation by some physiologists chiefly from the fact that when distant objects are viewed, the pupil becomes dilated; when near objects, contracted. In general such ~~objects~~ movements in the iris might be regarded as merely associate movements, the pupil contracting when the eye is turned inwards, as in the act of looking at a near object, and dilating when the eyes are turned outwards. But contraction of the pupil may ensue when by a voluntary effort, without any change in the position of the axes of the eyes, a near object is regarded; and dilatation of the pupil when a distant object is regarded. The iris may therefore co-operate for the production of distinct vision at different distances; but sufficient evidence that it is not the chief organ for the adaptation is furnished by the fact that individuals in whom the iris is wholly wanting may have perfect vision for near as well as distant objects.

The opinion now most commonly entertained of the adapting power of the eye, is, that it is mainly due to some alteration either in position or form or in both, undergone by the crystalline lens. The arguments stated by Hueck in favour of this view, are, first, that if the eye is watched attentively from the side, the iris will be observed

to bend forwards in

the middle, and approximated closer to the cornea, when a near object is viewed, and to become flattened again when the sight is fixed upon a distant object: Secondly, that when the fresh eye of a dog is removed and placed before a window, so that through an opening in the sclerotica, a distinct image of the window frame and an indistinct one of a smaller object, such as a key, held nearer to the eye, are perceived, the latter may be rendered distinct, and the former indistinct by drawing the lens forward with a needle inserted through the margin of the cornea.

By some it is supposed to be produced by vascular turgescence of the ciliary processes; the recedence of the lens ensuing on the cessation of the turgescence. By others and with greater probability, it is supposed to be effected by the contraction of muscular tissue situated in the neighbourhood of the ciliary body & processes.

The range of distances through which persons can adapt their power of vision is not in all cases the same. Some persons possess scarcely any power of adaptation, and of this defect of vision there are 2 kinds: one, in which the person can see objects distinctly only when brought close to the eye, having little power to discern distant objects: another, in which distant objects alone can be distinctly perceived, a small body being almost invisible except when held at a

considerable distance from the eye. In the one case the person is said to be short-sighted or myopic: in the other, long-sighted or presbyopic. Myopia is caused by anything, such as undue convexity of the cornea, which increases the refracting power of the eye, and so causes the image of an object to be formed at a point anterior to the retina: the defect is remedied by the use of concave glasses. Presbyopia or long-sightedness is the result of conditions the reverse of the above, and is remedied by the use of convex glasses, which diminish the focal distance of an image formed in the eye.

3. The direction given to the rays by their refraction is regulated by that of the central ray, or axis of the cone, towards which the other rays are bent. The image of any point of an object is therefore as a rule (the exceptions to which need not here be stated) always formed in a line identical with the axis of the cone of light, as in the line Ba, or Ab, fig 42: (diagram) so that the spot where any image of any point will be formed upon the retina may be determined by prolonging the central ray of the cone of light, or that ray which traverses the centre of the pupil. Thus Ab is the axis or central ray of the cone of light issuing from A: Ba, the central ray of the cone of light issuing from B: the image of

A is formed at b, the image of B at a, in the inverted position; therefore what in the object was above, is in the image below, and vice versâ — the right hand part of the object is in the image to the left, the left hand to the right.

If an opening be made in an eye at its superior surface, so that the retina can be seen through the vitreous humour, this inverted image of any bright object, such as the windows of the room, may be perceived at the bottom of the eye. Or still better, if the eye of any albino animal, such as a white rabbit, in which the coats, from the absence of pigment, are transparent, is dissected clean, and held with the cornea towards a window, a very distinct image of the window completely inverted is seen depicted on the posterior translucent wall of the eye. Dr Valkmann has also shewn that a similar experiment may be successfully performed in a living person possessed of large prominent eyes and an unusually transparent sclerotica.

No completely satisfactory explanation has yet been offered to account for the mind being able to form a correct idea of the erect position of an object of which an inverted image is formed on the retina. Muller and Volkmann are of opinion that the mind really perceives an object as inverted but needs no correction, since everything is seen alike inverted, and the relative position of the

objects the surface remains unchanged; and the only proof we can possibly have of the inversion is by experiment and the study of the laws of optics.

The perception of the erect position of objects appears therefore to be the result of an act of the mind.

Of some other properties of the retina and of the co-operation of the mind in the act of vision.

First of the ideal size of the field of vision. — The actual size of the field of vision depends on the extent of the retina, for only so many images can be seen at any one time as can occupy the retina at the same time; and thus considered, the retina, of which the affections are perceived by the mind is itself the field of vision. But to the mind of the individual the size of the field of vision has no determinate limits; sometimes it appears very small, at another time very large; for the mind has the power of projecting the images on the retina towards the exterior. Hence the mental field of vision is very small when the sphere of the action of the mind is limited by impediments near the eye; on the contrary, it is very extensive when the projection of the images on the retina towards the exterior by the influence of the mind is not impeded. It is very small when we look into a hollow body of small capacity held before the eyes; large when we look out upon a landscape through

a small opening; more extensive when we look at the landscape through a window; and most so when our view is not confined by any near object. In all these cases the idea which we receive of the size of the field of vision is very different, although its absolute size is in all the same, being dependent on the extent of the retina. Hence it follows that the mind is constantly co-operating in the acts of vision, so that at last it becomes difficult to say what belongs to mere sensation, and what to the influence of the mind.

By a mental operation of this kind, we obtain a correct idea of the size of individual objects as well as of the extent of the field of vision.

The direction in which an object is seen, the <u>direction of vision</u>, or <u>visual direction</u>, depends on the part of the retina which receives the image, and on the distance of this part from, and its relation to, the central point of the retina. Thus objects of which the images fall upon the same parts of the retina lie in the same visual direction; and when, by the action of the mind, the images or affections of the retina are projected into the exterior world, the relation of the images to each other remains the same.

The estimation of the <u>form of bodies</u> by sight is the result partly of the mere sensation, and partly of the association of ideas.

We judge of the motion of an object, partly from the motion of its image over the surface of the retina, and partly from the motion of our eyes following it. If the image upon the retina moves while our eyes and our body are at rest, we conclude that the object is changing its relative position with regard to ourselves. Sometimes the object appears to move when both object and eye are fixed, as in vertigo.

The mind can, by the faculty of attention, concentrate its activity more or less exclusively upon the senses of sight, hearing and touch alternately. We often when deep in thought have our eyes open and fixed, but see nothing, owing to the action of the fibres of the optic nerves being unable to excite the mind to perception when otherwise engaged.

The duration of the sensations of the retina is much longer than that of the impressions which produce them: according to Plateau, the sensation persists 0.32 to 0.35 of a second after the impression has ceased; and the duration of the after sensation or spectrum, is greater in a direct ratio with the duration of the impression which caused it.

The colour of the spectrum varies with that of the object which produced it. The spectra left by the images of white or luminous objects are ordinarily white or luminous; those left by dark objects are dark. Sometimes, however, the

relation of the light and dark parts in the image may under certain circumstances, be reversed in the spectrum; what was bright may be dark, and what was dark may appear light. This occurs whenever the eye which is the seat of the spectrum of a luminous object is not closed, but fixed upon another bright or white surface, as a white wall or a sheet of white paper. Hence the spectrum of the sun, which while light is excluded from the eye, is luminous appears black or grey when the eye is directed upon a white surface. The explanation of this is that the part of the retina which has received the luminous image remains for a certain period afterwards in an excited state, while that which has received a dark image is in an unexcited, and therefore much more excitable, condition.

The ocular spectra which remain after the impression of coloured objects upon the retina are always coloured; and their colour is, not that of the object, or of the image produced directly by the object, but the opposite, or complemental colour. The spectrum of a red object is, therefore green; that of a green object, red; that of violet yellow; that of yellow, violet, and so on.

The colours which thus reciprocally excite each other in the retina are those placed at opposite points of the circle in this diagram.

(See fig 44 Kirbies p 341)

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Anatomy of the Ear.

Geo. D. Gibb M.D.

31st January 1852.

To illustrate

Large coloured diagram of the ear

Todd figs 132. 134. 135. 136. 137. 138
139. 140. 141. 142. 143. 144

Various Otolites -

Anatomy of the Ear.

It is by the sense of hearing that the mind takes cognizance of those oscillations of elastic matter which give rise to the phenomena of sound.

The communication of the oscillations to the ear may take place through the air, or through the intervention of some solid conductor, brought into immediate connexion with the organ of hearing. The essential part of the organ of hearing is a sac, containing fluid, upon which the nerve of hearing is freely distributed: this sac being in connexion with the cranial parietes. This is represented in the human subject by that small cavity which is excavated in the petrous portion of the temporal bone, called the vestibule. This, and three semi-circular canals, with a spirally disposed canal, divided by a partition, constituting the cochlea, form the labyrinth. External to this, and situate between the squamous and petrous portions of the temporal bones is a cavity, the tympanum, which in front further communicates very freely with the cavity of the throat through an open channel, the Eustachian tube, whereby air has a free access to the tympanum. This cavity is closed on the outside by a membrane (membrana tympani) which extends over its external orifice as over a drum. A com-

munication is established between the membrane and the inner wall of the tympanum, by a chain of small bones which extends from the one to the other. These are the ossicles of the ear. The outer bone of the chain is intimately attached to the membrana tympani, and the inner one to a membrane which closes the vestibule on the outside. The 3 bones which compose the chain are articulated by moveable joints, and are moved by small muscles, which are thus enabled to regulate the tension of the membrana tympani, as well as of the membrane of the vestibule. Externally is an apparatus for collecting sounds and conducting them to the tympanum.

In examining the anatomy of the human ear, we shall first describe the external ear, then the middle ear or tympanum, and lastly the labyrinth.

The External Ear comprises the free, expanded part, auricle or pinna, and the auditory canal or external meatus.

The auricle presents an outer surface, which is on the whole concave, and slightly inclined forwards. The cartilage of the pinna consists of one principal piece, it is very flexible & elastic, has a yellowish colour, and belongs to the same category as the cartilages of the alae nasi, &c. The whole of the cartilaginous part of the ear, is

is rendered moveable by 3 muscles, the superior, posterior and anterior auris.

The auditory canal passes from the concha inwards for about an inch, or rather more. It inclines a little forwards, and is slightly bowed, so as to be higher near the middle than at either end. Its width does not equal its height, and it is altogether narrower in the middle. The membrana tympani, which terminates it, is placed obliquely in consequence of the lower side of the meatus being longer than the upper. The canal consists of 2 parts, a cartilaginous & fibrous one, and an osseous. Muscular fibres are described by some to exist in the meatus, which according to Haller becomes shortened by their contraction. The osseous part of the canal auditory consists in the form of a ring of bone, to which the membrana tympani is attached (tympanic ring of the temporal bone). In the adult, it is is nearly 3/4 of an inch long, & pursues the meatus the former direction already described.

The skin of the external ear is delicate, and well supplied with vessels and nerves. The orifice of the meatus, besides being concealed behind the tragus is defended by hairs, and a close arrangement of ceruminous glands, which furnish an abundant secretion, calculated to entangle particles of dust, or small insects, and to prevent their entrance into the organ. These glands are principally seated in the subcutaneous tissue,

where the cartilage is deficient, and do not extend into the osseous portion of the canal. The cerumen is an oily, very bitter substance, of a yellow colour, and contains, in addition to fat, albumen & colouring matter, a bitter principle analogous to that of the bile. If not removed from time to time, it is liable to form hard pellets, which either impede the passage, or come into contact with the membrana tympani, and in either case seriously interfere with the transmission of sound to the internal parts. These concretions are partially soluble in ether and turpentine.

The Middle Ear or tympanic cavity, is a space filled with air, communicating with the pharynx by the Eustachian tube, and interposed between the external meatus and the labyrinth. It opens behind into the mastoid cells, which are also filled with air, and it is traversed by a chain of moveable bones, connecting the membrana tympani with the vestibule or common central cavity of the labyrinth. The tympanum is of irregular shape, compressed laterally, and lined by a very delicate ciliated epithelium, prolonged from the pharynx.

The external wall of the tympanum is formed by the membrana tympani, and a small extent of the surrounding bone. The membrane is nearly oval, but wider above than below, & as already stated placed in a slanting direction. It consists of 3 laminae, an external, middle, & internal.

The external is derived from the cuticular lining of the canal, and easily detaches itself with that structure after maceration. The middle is strong and fibrous, perhaps analagous to the dermal part of the integument, and attached through the medium of adense fibrous rim to the bone, which presents a distinct groove for its reception, except above. The handle of the malleus is firmly united to this layer of the membrane, in a vertical direction as far down as the centre, and draws the membrane inwards along that line, so that its outer surface is concave, its inner convex. The inner layer is the ciliated epithelial lining of the cavity, which is easily scraped off for examination in the fresh state.

The internal wall of the tympanum (fig 132 bold) has 2 orifices of communication with the internal ear; the fenestra ovalis, a, leading to the vestibule, and the fenestra rotunda, b, opening into the cochlea. Both these are closed by membrane which prevents the escape of the fluid contained in these inner chambers and communicating ramifications to it. The fenestra ovalis is likewise occupied by the base of the stapes, one of the chain of ossicles connecting it with the membrana tympani. Between the fenestrae is the promontory c, corresponding to the first turn of the cochlea. Behind the fenestra ovalis is a conical eminence the pyramid, d, hollowed, and presenting a small orifice at its summit, which is on a level with

the middle of the vestibular fenestra.

The anterior part of the tympanum presents above the canal for the tensor tympani muscle, and below the orifice of the Eustachian tube. The former, i, is chiefly formed by a curled plate of bone, the processus cochleariformis, g, ending in a kind of perforated summit, that some have termed, anterior pyramid. This is a little above the fenestra ovalis, and gives passage to the tendon of the tensor tympani, which becomes attached to the short process of the malleus.

The Eustachian tube, about 1 inch and a half in length, leads from the tympanum downwards, forwards and inwards to its orifice in the pharynx, which is seen as a slit with an elevated edge close behind the inferior turbinated bone of the nose (see fig 106, t, Todd). By its straight but inclined course the passage of mucus from the tympanum is facilitated. Its upper extremity for more than half an inch is bony, while in the rest of its extent it is cartilaginous. It dilates at each end, especially the lower, where the cartilage is thickened and curled. It forms a passage for the air in and out of the tympanum. It exists in all animals in which a tympanum is found, but in many, the tubes of opposite sides have a common outlet on the pharynx.

The ossicles of the tympanum, are three, the

malleus, incus and the stapes. (fig 133 Todd & show specimens.)

These bones are moved by small muscles, 2 of which are not disputed. These are the internal muscle of the malleus, and the stapedius muscle. Each of these muscles consists of striped fibres.

These bones and muscles will be particularly described by the Lecturers on Anatomy, and Dental Surgery.

Of the Internal Ear, or Labyrinth. — This is the essential part of the organ of hearing, & includes the ultimate distribution of the nerve. It consists of 3 parts, the vestibule, the semi circular canals and the cochlea, all of which, from their delicacy and minuteness of structure, require demand careful examination. They are a series of cavities hidden in the hardest part of the petrous bone, communicating on the outside with the tympanum, by the fenestrae ovalis and rotunda already described, and on the inside with the internal auditory canal, which conveys the nerve to them. The very compact bone immediately bounding these cavities, considered apart from the less dense bone which surrounds it, is termed the osseous labyrinth, in distinction from a membranous labyrinth within.

Of the osseous Labyrinth. The singularly complex shape of this part of the organ makes it difficult to describe. 1. The Vestibule or common central cavity, placed immediately to the inner side of the

tympanum, is flattened from side to side, and about a fifth of an inch in height, as well as from before backwards. The semi circular canals open into it by 5 orifices from behind, the cochlea by a single one in front; on its outer wall is the fenestra ovalis, on its inner several minute holes, including the macula cribrosa for the entrance of a portion of the auditory nerve from the internal auditory meatus. At the hinder part of the inner wall is the orifice of the aqueductus vestibuli, a fine canal penetrating the vestibule from the posterior surface of the petrous bone; it seems to convey small vessels to the internal ear. The lower part of the inner wall presents a hemispherical depression (fovea hemispherica), and immediately above it, and on the upper wall, another, transversely oval and larger (fovea semi-elliptica). These are separated by a small pyramidal eminence.

2. The semi-circular canals are 3 in number, all opening at both ends into the vestibule, so that there would be 6 orifices, were not one of the orifices common to 2 of the canals. The canals are of unequal length, but all describe more than half a circle, and their cavity is not cylindrical, but slightly compressed on the sides, and about a twentieth of an inch in diameter. Each is dilated at one end into an ampulla, of more than twice the diameter of the tube, and at the opposite end it opens out slightly on entering the vestibule. Each canal lies in a different plane, the direction of which being constant, should be carefully noticed in relation

& third function. The superior canal vertical is also anterior, and lies across the petrous bone, it forms about 2/3 of a circle, and its extremities are more divergent than those of the others. The inferior vertical canal, is also posterior, and runs parallel to the posterior surface of the petrous bone, & therefore at right angles to the former. The horizontal canal is also inferior and shorter than either of the others, its arch is directed outwards and backwards.

3. The cochlea is in shape very like a common snail shell. It lies almost horizontally, its apex forwards and outwards, its base marked near the bottom of the internal meatus, by a depression exhibiting a spiral arrangement of pores for the reception of the cochlear division of the auditory nerve. From base to apex extends the irregularly conical axis, modiolus, or columella, which is perforated by numerous branching channels, ascending from the pores just mentioned, & distributing the nervous filaments in regular succession within the spiral cochlear canal which winds around the axis. This spiral canal is about 1½ inches in length, if measured along its outer wall, & diminishes gradually in size from the base to the summit of the cochlea, where it ends in a cul de sac. At its commencement it is about 1/10th of an inch in diameter, but at its termination nearly half that size. At its base it diverges somewhat from the modiolus, towards the tympanum and vestibule, & presents 3 openings.

of these, one, free and oval, enters the vestibule; another is the fenestra rotunda, communicating with the tympanum in the dry bone, but filled up in the recent state by a proper membrane, the membrana tympani secondaria; the third is the minute orifice of the aqueductus cochleae, a funnel shaped canal leading to the jugular fossa, and supposed to transmit a small vein. The spiral canal describes about 2 turns and a half, of which the first, passing round the large base of the modiolus, takes much the widest sweep, so as to encircle most of the second turn. The inner wall of this coiled canal, as has been shown by Stg, forms the outer wall of the modiolus.

The spiral canal of the cochlea is subdivided into 2 passages by an osseo-membranous lamina, extended between its modiolar and peripheral wall, and of course taking the same spiral direction as the canal itself. This is the lamina spiralis, the fundamental element of the cochlea, on which the nervous tubules are spread out. More than half its breadth on the side of the modiolus is formed by a very little osseous process from the modiolus, called the osseous zone, enclosing minute channels continuous with those of that part, and transmitting the nerves; its opposite or outer portion is membranous and muscular, and connects the outer thin edge of the osseous zone to the outer wall. The osseous zone commences gradually within the vestibule, & enters the spiral

canal between the vestibular and tympanic openings of the cochlea, forming, with the help of the membranous extension, a complete septum between them. The passages or scalae, into which the spiral lamina divides the canal, correspond, therefore, respectively to these chambers; the upper towards the apex of the cochlea, scala vestibuli; the lower towards its base, scala tympani. These scalae are, on the whole, pretty equal in size; the vestibular scala is, however, the smaller at the base, the tympanic near the apex of the coil; and the latter ceases ere it reaches the summit. At the apex of the cochlea the parts have an arrangement difficult to describe, though easily understood when seen. The axis, no longer hollow, and containing nerves, is reduced to a delicate lamella at about half a turn from the dome like summit, or cupola, formed by the last part of the spiral canal. This lamella which is the real apex of the modiolus, immediately expands, stretches upwards, and becomes more twisted on itself, so as to include part, or all of the last half turn of the cochlear canal, being termed from its appearance as viewed from below, the infundibulum, or funnel. The wide part of this infundibulum is directed towards the cupola, with which it blends. It is not open above, but on the side, and it is, in fact the outside of the last half turn of the canal, projecting into the turn below.

The cavity of the osseous labyrinth is occupied by a limpid fluid the perilymph, surrounding the

membranous labyrinth, which latter itself contains a similar fluid, the endolymph.

Of the Structure of the Spiral Lamina of the Cochlea.

We shall term the 2 surfaces of this lamina, tympanic and vestibular, as they regard respectively the tympanic or vestibular scala. The osseous portion of the spiral lamina extends more than half way from the modiolus towards the outer wall, and is perforated, as already described, by a series of plexiform canals for the transmission of the cochlear nerves; these canals, taken as a whole, lie close to the lower or tympanic surface, and open at or near the margin of the zone. The vestibular surface of the osseous zone presents in about the outer fifth of its extent, a remarkable covering, more resembling the texture of cartilage than anything else, but having a peculiar arrangement quite unlike any other with which we are acquainted. It is called by Todd & Bowman the denticulate lamina (figs 137 and 138) from a beautiful series of teeth, forming its outer margin, which project free into the vestibular scala, and in the first coil, terminate almost on a level with the margin of the osseous zone, but more within this margin towards the cochlea apex of. They thus constitute a kind of second margin to the osseous zone, on the vestibular side of the true margin, and having a groove beneath them, which runs along the whole lamina spiralis, in the vestibular scala, immediately above the true margin of the osseous zone. The intervals between the teeth are to be seen on their upper surface, or their free edge,

and also within this groove, so that the teeth are wedge-shaped, and their upper and under surfaces, traced from the free edge, recede. The free projecting part, or teeth of the denticulate lamina form less than a fourth of its entire breadth, and in the remainder of its extent it appears to rest on the osseous zone; seen from above, after the osseous zone has been rendered more transparent by weak hydrochloric acid (fig 138) rows of clear lines may be traced from the teeth at the convex edge, towards the opposite or concave edge of the lamina. These lines appear to be a structure resembling that of the teeth themselves, and they are separated from one another by rows of clear, highly refracting granules, which render the intervals very distinct. These intervals, as seen in the figure, are more or less sinuous and irregularly branched.

The denticulate lamina, thus placed on the vestibular surface of the osseous zone, is above, & at some distance from the plexus of the cochlear nerves, which lies near its tympanic surface. The vestibular surface of the osseous zone, including the denticulate lamina, is convex, rising from the free series of teeth towards the modiolus.

In the groove already mentioned there is a series of elongated bodies, not unlike columnar epithelium in which the nuclei are very faint. These bodies are thick and cubical at one end, and taper much towards the other. They are united in a row; and it is possible they may have some analogy to the club-shaped bodies of Jacobs Membrane.

Continuous with the thin margin of the osseous zone is the membranous zone. This is a transparent glassy lamina, having some resemblance to the elastic laminae of the cornea and the capsule of the lens. A narrow belt of it next the osseous zone is smooth and exhibits no internal structure, while in the rest of its width it is marked by a number of very minute straight lines, radiating outwards from the side of the modiolus. These lines are very delicate at their commencement, become more strongly marked in the middle, and are again fainter ere they cease, which they do at a curved line on the opposite side. Beyond this the membranous zone is again clear, and homogeneous, and receives the insertion of the cochlearis muscle. The inner clear belt of the membranous zone is little affected by acids. It seems hard and brittle. The middle or pectinate portion is more flexible, and tears in the direction of the lines. The outer clear belt is smaller and partially destroyed by the action of acetic acid.

The cochlearis muscle fills up the groove on the outer wall of the cochlear canal, ascending the entire coil, opposite the osseous zone of the lamina spiralis; it forms the muscular zone of the spiral lamina.

Of the cochlear nerves. These enter from the internal auditory meatus through the spirally-arranged orifices at the base of the modiolus, and turn over in succession into the canals hollowed in the osseous zone of the spiral lamina, close to its tympanic surface. In this distribution the nervous bundles subdivide and reunite again and again, forming a

plexus with elongated meshes, the general radiating arrangement of which can be readily seen through the substance of the bone when it has been steeped in dilluted hydrochloric acid (fig 141) (see also Hassall.) Towards the border of the osseous zone the bundles of the plexus are smaller and more closely set, so as at length almost to form a thin uniform layer of nervous tubules. The white substance of Schwann exists in them throughout.

Of the membranous labyrinth (fig 142.) This has the same general shape as the bony cavities in which it lies, but is considerably smaller, so that the perilymph intervenes in some quantity, except where the nerves passing to it confine it in a close contact with the osseous wall.

The membranous semicircular canals have the same names, shape, and arrangement as the osseous canals which enclose them, but are only a third of the diameter of the latter. As the osseous canals open into the vestibule, so the membranous ones open at both ends into the utriculus — there being however, a constricted neck between this sac and the ampullated extremity of each canal.

A beautiful network of capillaries, forcibly reminding the observer of that belonging to the retina, is spread out on the outer surface and in the substance of the proper coat of the membranous labyrinth. The membranous labyrinth, or its simple representative the auditory sac, contains, in all animals, either solid or pulverulent calcareous matter, in connexion with the termination of the vestibular nerves. This is the otolith, or ear stone,

when solid, as in the osseous fishes, (show specimens) and otoconia, or ear powder, when in the form of minute crystalline grains, as in mammalia, birds, and reptiles, but the former term may be employed to designate both varieties.

Otoliths consist always of carbonate of lime.

Of the Vestibular nerves, the nervous twigs belonging to the semicircular canals do not seem to advance beyond the ampullae, in which they have a remarkable distribution, entering them, as Steifensand has well shown, by a transverse or forked groove on their concave side, and which reaches about a third round. Within this, the nerve projects so as to form a sort of transverse bulge within the ampulla. Their precise termination can be best seen in the osseous fishes, and has been described by Wagner & Leydig, as in (fig 144.)

Of the Auditory Nerve. The portio mollis of the 7th pair has its origin from the med: oblong by 2 roots, (Todd p 85), these converge in the linear transversa of the anterior wall of the 4th ventricle, & the nerve winds around the Corpus restiforme, & the posterior part of the cms cerebelli. This nerve when contrasted with the other nerves of the med: oblong: is remarkable for its delicacy of structure, a character which had attracted the attention of the older anatomists, & hence derived the name of "mollis". It has but a very delicate neurilemma, and its fascicles are loosely held together.

The portio mollis enters the internal auditory foramen and there forms a connexion with the portio dura, by means of a few fascicles of fibres, which constitute the

"partio intermedia" of Wrisberg. It is most reasonable to suppose that the muscular nerve, (the facial) windsome filaments into the labyrinth & the blood vessels, and to the muscular structure of that portion of the ear.

At the bottom of the meatus, the partio mollis divides into 2 branches, one to the vestibule and semicircular canals, the other to the cochlea.

The vestibular nerve divides into 3 branches.

That the partio mollis is the nerve of hearing is abundantly proved by the following arguments:—

1. The distribution of the nerve to the internal ear, to which no other nerve of any importance is distributed.

2. Its softness of texture and cerebriform character distinguish it from ordinary nerves of sensation & motion.

3. Diseased states of it or of parts immediately near to its origin affect the sense of hearing, whilst a paralytic state of the partio dura or of the 5th does not affect the ~~same~~ sense.

Besides the auditory nerve there are others which influence the auditory apparatus. These are branches of the partio dura, branches of the nerve of Jacobson, from the glossopharyngeal, & from the otic ganglion. These nerves present a striking analogy with those which are distributed to the eye.

The tympanum receives branches from the facial, and glossopharyngeal, & probably from the sympathetic.

The external ear is supplied by the facial, as regards its muscular apparatus, and by the 5th pair as regards its sentient surfaces.

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Physiology of Hearing.

Geo. D. Gibb M.D.

7th February 1852

The following points should be borne in mind respecting the laws of sound, in considering the offices of the various parts of the ear.

in Todd page 87 Vol 2. Carpenters Manual p. 552

1. Vibrations excited in solid bodies may be transmitted to water without much loss of their intensity; although not with the same readiness that they would be communicated to another solid.

2. On the other hand, vibrations excited in water lose something of their intensity on being conveyed or propagated to solids; but they are returned as it were, by these solids to the liquid, so that the sound is more loudly heard in the neighbourhood of these bodies, than it would otherwise have been.

3. The sonorous vibrations are much more weakened in the transmission of solids to air; and those of air make but little impression on solids.

4. Sonorous vibrations in water are transmitted but feebly to air; and those which are taking place in air are with difficulty communicated to water; but the communication is rendered more easy, by the intervention of a membrane extended between them.

Physiology of Hearing.

Functions of the External Ear.

The external ear consists of 2 parts, the auricle, and the meatus auditorius externus. The complete development of the former is found only in mammalia, in which class it exists pretty generally; with however considerable diversity of form, varying from what appears to be little more than a mere cartilaginous lamella with a few irregularities upon its surface, ranging scarcely any motion, to an elongated funnel-shaped ear trumpet, very moveable, and completely under the control of numerous large muscles. Man and the quadrumana are at one extremity of this scale; the solipeds, the ruminants, & the bats at the other.

That the auricle performs the office of an acoustic instrument to collect and reinforce the sounds which fall upon it, cannot be doubted in those cases in which it is large and fully developed, as in the horse, ass, &c. These animals employ it as we might expect such an instrument would be used; the open part is directed towards the quarter whence the sound comes, & continues so directed as long as the animal appears to listen.

The external auditory passage influences the propagation of sound to the tympanum in 3 ways:—

1. The sonorous undulations, entering directly from the atmosphere, are transmitted by the air in the passage immediately to the membrana tympani, and are prevented

To illustrate

large diagram of external car
large coloured do of entire car.
drawing of Kitchen No 53
Auditory nerve from Duain.

tympanum being disposed. 2 by the walls of the passage conducting the sonorous undulations imparted to the external ear itself, by the shortest path to the attachment of the membrana tympani, and so to this membrane. 3 by the resonance of the column of air contained within the passage.

As a conductor of undulations of air, the external auditory passage receives the direct undulations of the atmosphere, of which those that enter in the direction of its axis produce the strongest impression. The undulations which enter the passage obliquely are reflected by its parietes, and thus by reflexion reach the membrana tympani. By reflexion, also the external meatus receives the undulations which impinge upon the concha of the external ear, when their angle of reflexion is such that they are thrown towards the tragus. Other sonorous undulations again, which could enter the meatus from the external air neither directly nor by reflexion, may still be brought into it by inflexion; undulations for instance whose direction is that of the long axis of the head, and which pass over the surface of the ear, must, in accordance with the laws of inflexion, be bent into the external meatus by its margins. But the action of those undulations which enter the meatus directly are most intense: and hence we are enabled to judge of the point whence sound comes, by turning our ear in different directions, till it is directed to the point

whence the vibrations may pass directly into the meatus and produce the strongest impression.

The walls of the meatus are also solid conductors of sound; for those vibrations which are communicated to the cartilage of the external ear, and not reflected from it, are propagated by the shortest path through the parietes of the passage to the membrana tympani. Hence, both ears being close stopped, the sound of a pipe is heard more distinctly when the lower extremity covered with a membrane, is applied to the cartilage of the external ear itself, than when it is placed in contact with the surface of the head.

Lastly the external auditory passage is important, as the air which it contains, like all insulated masses of air, increases the intensity of sounds by resonance. To prove this, we need only lengthen the passage by affixing to it another tube: every sound that is heard, even the sound of our own voice, is then much increased in intensity.

The action of the Cartilage of the external ear upon sonorous vibrations is partly to reflect them, and partly to condense and conduct them to the parietes of the external passage. With respect to its reflecting action, the Concha is the most important part, since it directs the reflected undulations towards the tragus, whence they are reflected into the auditory passage. The other inequalities of the external ear do not promote hearing by reflection;

and, if the conducting power of the cartilage of the ear were left out of consideration, they might be regarded as destined for no particular use; but receiving the impulses of the air, the cartilage of the external ear, while it reflects a part of them, propagates within itself and condenses the rest, as all other solid and elastic bodies would do.

Regarding the cartilage of the external ear, therefore, as a conductor of sonorous vibrations, all its inequalities, elevations, and depressions, which are useless with relation to reflexion become of evident importance; for those elevations and depressions upon which the undulations fall perpendicularly, will be affected by them in the most intense degree; and, in consequence of the various form & position of these inequalities, sonorous undulations, in whatever direction they may come, must fall perpendicularly upon the tangent of some one of them. This affords an explanation of the extraordinary form given to this part.

Functions of the Middle Ear; the Tympanum Ossicula, and Fenestrae.

In animals living in the atmosphere the sonorous vibrations are conveyed to the auditory nerve by 3 different media in succession; namely, the air, the solid parts of the body of the animal and of the auditory apparatus, and the fluid of the labyrinth.

Sonorous vibrations are imparted too imperfect-

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from air to solid bodies, for the propagation of sound to the internal ear to be adequately effected by that means alone: yet already an instance of its being thus propagated has been mentioned.

In passing from air directly into water, sonorous vibrations suffer also a considerable diminution of their strength; but if a tense membrane exists between the air and the water, the sonorous vibrations are communicated from the former to the latter medium with very great intensity. This fact of which Müller gives experimental proof, furnishes at once an explanation of the use of the fenestra rotunda, and of the membrane closing it. They are the means of communicating in full intensity the vibrations of the air in the tympanum to the fluid of the labyrinth. This peculiar property of membranes is the result, not of their tenuity alone, but of the elasticity and capability of displacement of their particles; and it is not impaired, when, like the membrane of the fenestra rotunda, they are not impregnated with moisture.

Sonorous vibrations are also communicated without any perceptible loss of intensity from thin air to the water, when to the membrane forming the medium of communication there is attached a short solid body, which occupies the greater part of its surface, and is alone in contact with the water. This fact elucidates the action of the fenestra ovalis, and of the plate of the stapes

which occupies it; and with the preceding fact, shews that both fenestrae — that closed by membrane only, and the other with which the moveable stapes is connected — transmit very freely the sonarous vibrations from the air to the fluid of the labyrinth.

A small solid body, fixed in an opening by means of a border of membrane, so as to be moveable, communicates sonarous vibrations, from air on one side, to water, or the fluid of the labyrinth, on the other side, much better than solid media not so constructed. But the propagation of sound to the fluid is rendered much more perfect if the solid conductor thus occupying the opening, or fenestra ovalis, is by its other end fixed to the middle of a tense membrane, which has atmospheric air on both sides.

A tense membrane is a much better conductor of the vibrations of air than any other solid body bounded by definite surfaces; and the vibrations are also communicated very readily by tense membranes to solid bodies in contact with them. Thus then, the membrana tympani serves for the transmission of sound from the air to the chain of auditary bones. Stretched tightly in its osseous ring, it vibrates with the air in the auditary passage, as any thin tense membrane will when the air near it is thrown into vibrations by the sounding of a tuning fork or a musical string. And, from such a tense vibrating membrane, the vibrations

re communicated with great intensity to solid
odies which touch it at any point. If, for ex=
mple, one end of a flat piece of wood be applied
the membrane of a drum while the other end is
eld in the hand, vibrations are felt distinctly
hen the vibrating tuning fork is held over the
membrane without touching it; but the wood
alone, isolated from the membrane, will only
ery feebly propagate the vibrations of the air
the hand.

The ossicula of the ear, which are represen
ted in this experiment by the piece of wood, are
the better conductors of the sonorous vibrations
ommunicated to them, on account of being
isolated by an atmosphere of air, and not contin
uous with the bones of the Cranium; for every
solid body thus isolated by a different medium
ropagates vibrations with more intensity through
its own substance than it communicates them
the surrounding medium, which thus prevents
e dispersion of the sound; just as the vibrations
f the air in the tubes used for conducting the
oice from one apartment to another are pre=
ented from being dispersed by the solid walls
f the tube. The vibrations of the membrana
tympani are transmitted, therefore, by the
hain of ossicula to the fenestra ovalis & fluid
f the labyrinth, their dispersion in the tympanum

being prevented by the difficulty of the transition of vibrations from solid to gaseous bodies. The membrana tympani being a tense solid body bounded by free surfaces, the sonorous undulations will be partially reflected at its surfaces, so as to cause a meeting of opposite undulations from opposite directions within it; it will therefore, by resonance, increase the intensity of the vibrations communicated to it, and the undulations thus rendered more intense will act in their turn upon the chain of auditory bones.

The oscillations of the membrana tympani as a whole, produced by very intense sounds, will, if the undulations of the air fall upon the membrane in a perpendicular direction, occupy its whole extent at once; but if the undulations of the air fall upon it obliquely, so as to strike one part of it before the rest, the movement of the membrane will continue at this point, and will thence extend to the other parts, like the oscillation which is excited near one extremity of a musical string, or at one limited part of the membrane of a drum. These oscillations, being reflected at the borders of the membrane, will traverse it to and fro.

The necessity for the presence of air on the inner side of the membrana tympani to enable it and the ossicula auditus to fulfil the objects just described, is obvious. Without this provision, neither would the vibrations

of the membrane be free, nor the chain of bones isolated, so as to propagate the sonorous undulations with concentration of their intensity. But while the oscillations of the membrana tympani are readily communicated to the air in the cavity of the tympanum, those of the solid ossicula will not be conducted away by the air, but will be propagated to the labyrinth without being dispersed in the tympanum. Equally necessary is the communication of the air in the tympanum with the external air through the medium of the Eustachian tube for the maintenance of the equilibrium of pressure and temperature between them.

The long process of the malleus receives the undulations of the membrana tympani* (a. a) and of the air in a direction, indicated by the arrows nearly perpendicular to itself. From the long process of the malleus they are propagated to its head (b); thence to the incus (c), the long process of which is parallel with the long process of the malleus. From the long process of the incus the undulations are communicated to the stapes (d), which is united to the incus at right angles. All these changes in the direction of the chain of bones have, however, no influence on that of the undulations, which remains the same as it was in the meatus externus and long process of the malleus, so that the undulations are communicated by the stapes to the fenestra ovalis in a perpendicular direction.

* fig 53 Kirkes –

Increasing tension of the membrana tympani diminishes the facility of transition of sonorous undulations from the air to it. M. Savart observed that the dry membrana tympani, on the approach of a body emitting a loud sound, rejected particles of sand strewn upon it more strongly when lax than when very tense; and inferred, therefore, that hearing is rendered less acute by increasing the tension of the membrana tympani. Muller has confirmed this by experiments with small membranes arranged so as to imitate the membrana tympani: and it may be confirmed also by observation on one's self. explain how. p 564 Kirkes

The principal office of the Eustachian tube is chiefly to allow the free ingress of air into the tympanic cavity in order to provide for the due vibration of the membrana tympani and of the chain of bones. It also, by permitting a free egress of air, renders the tympanum a non reciprocating cavity, and therefore abrogates the production of echoes in it, which would materially interfere with perfect hearing. The importance of the Eustachian tube to the integrity of hearing is well known to all practical men by the deafness which always accompanies chronic or acute disease of the tonsils, or occlusion of the canal of that tube from any other cause.

The influence of the tensor tympani muscle in modifying hearing may also be probably explained in connection with the regulation of the tension of the membrana tympani.

the influence of the stapedius muscle in hearing is unknown. It acts upon the stapes in such a manner as to make it rest obliquely in the fenestra ovalis, depressing the side on which it acts, and elevating the other side to the same extent.

When the fenestra ovalis & fenestra rotunda exist together with a tympanum, the sound is transmitted to the fluid of the internal ear in 2 ways, — namely, by solid bodies and by membrane; by both of which conducting media sonorous vibrations are communicated to water with considerable intensity. The sound being conducted to the labyrinth by 2 paths will, of course, produce so much the stronger impression; for undulations will be thus excited in the fluid of the labyrinth from 2 different though continuous points, and by the crossing of these undulations, stationary waves of increased intensity will be produced in the fluid.

Functions of the Labyrinth.

The fluid of the labyrinth or perilymph is the most general and constant of the acoustic provisions of the labyrinth. In all forms of organs of hearing, the sonorous vibrations affect the auditory nerve through the medium of a fluid: and the reason for this provision is probably to be found in the following circumstances. The ultimate purpose of the organ of hearing is to impart, as perfectly as possible, the impulses of the

sonorous vibrations to the fibres of the auditory nerve. This nerve being soft, and, like all nerves, impregnated with water, sonorous undulations, if directly communicated to it from solid parts, would be partly converted into undulations of fluid, before producing their impression on the fibres. Besides however, the impregnation of the nervous fibres with water, on which their softness depends, all the interspaces between the fibres are, as in all soft tissues, filled with fluid matter, either blood or the fluid of cellular membrane. Hence the auditory nerve, in receiving the sonorous undulations through the medium of the fluid of the labyrinth, receives them from a medium of the same kind as that which occupies all the pores and interstices of the nervous fibres themselves. On this account, the vibration of the particles in the nerve itself will probably be much more uniform in character than if the surfaces of the nerve had been in contact with solid parts; in which case, the more internal particles of the nerve, being distant from the surface of the solid bone, would be acted on in a different manner from the more superficial particles.

The function usually ascribed to the <u>Semicircular Canals</u> is the collecting, in their fluid contents, the sonorous undulations from the bones of the cranium. They have probably, also, in some degree the power of conducting sounds in the direction of their curved cavities more easily

than the sounds are carried off by the surrounding hard parts in the original direction of the undulations, though this conducting power is in them much less perfect than in tubes containing air.

Admitting that they have these powers, the increased intensity of the sonorous vibrations thus attained will be of advantage in acting on the auditory nerve where it is expanded in the ampullæ of the canals, and in the utriculus. Where the membranous canals are in contact with the solid parietes of the tubes, this action must be much more intense. But the membranous semicircular canals must have a function independent of the surrounding hard parts; for in the Petromyzon* they are not separately enclosed in solid substance, but lie in one common cavity with the utriculus.

The crystalline pulverulent masses in the labyrinth would impart the sonorous vibrations by their resonance, even if they did not actually touch the membranes upon which the nerves are expanded; but as these bodies lie in contact with the membranous parts of the labyrinth, and the vestibular nerve fibres are imbedded in them, they communicate to these membranes and the nerves vibratory impulses of greater intensity than the fluid of the labyrinth can impart. This appears to be the office of the otoconia. Sonorous undulations in water are

* Lamprey tribe of Fishes

not perceived by the hand itself immersed in the water, but are felt distinctly through the medium of a rod held in in the hand.

The cochlea seems constructed for the spreading out of the nervous fibres over a wide extent of surface, upon a solid lamina communicating with the solid walls of the labyrinth & cranium, at the same time that it is in contact with the fluid of the labyrinth; and which, besides exposing the nervous fibres to the influence of sonorous undulations by 2 media, is itself insulated by fluid on either side. See chart plate, of spreading out of auditory nerve, from Quain.

The connexion of the lamina spiralis with the solid walls of the labyrinth adapts the cochlea for the perception of the sonorous undulations propagated by the solid parts of the head and the walls of the labyrinth. The membranous labyrinth of the vestibule and semicircular canals is suspended free in the perilymph, and is destined more particularly for the perception of sounds through the medium of that fluid, whether the sonorous undulations are imparted to the fluid through the fenestrae, or by the intervention of the cranial bones, as when sounding bodies are brought into communication with the head or teeth. The spiral lamina on which the nervous fibres are expanded in the cochlea is, on the contrary, continuous with the solid walls of the labyrinth, and receives

directly from them the impulses which they transmit. This is an important advantage; for the impulses imparted by solid bodies have, caeteris paribus, a greater absolute intensity than those communicated by water. And, even when a sound is excited in the water, the sonorous undulations are more intense in the water near the surface of the vessel containing it than in other parts of the water equally distant from the point of origin of the sound; hence we may conclude that caeteris paribus, the sonorous undulations of solid bodies act with greater intensity than those of water. Hence we perceive at once an important use of the cochlea.

This is not, however, the sole office of the cochlea; the spiral lamina, as well as the membranous labyrinth, receives sonorous impulses ~~from~~ through the medium of the fluid of the labyrinth from the cavity of the vestibule and from the fenestra rotunda. The lamina spiralis is, indeed, much better calculated to render the action of these undulations upon the auditory nerve efficient, than the membranous labyrinth is; for, as a ~~solid~~ body insulated by a different medium, it is capable of resonance.

Lastly, it may be observed that the fibres of the nerve being spread out simply upon the lamina spiralis is advantageous, because in the first place, it ensures a more complete participation of the fibres in the impulses communicated

by the solid parts of the cochlea; and, secondly, the intensity with which the sonorous undulations are communicated to a body is proportionate to the extent of surface over which they can act on it.

The faculty of Hearing, like other senses, may be very much increased ~~by~~ in acuteness by cultivation but this improvement depends rather upon the habit of attention to the faintest impressions made upon the organ, than upon any change in the organ itself. This habit may be cultivated in regard to sounds of some one particular class; all others being heard as by an ordinary person. Thus, the watchful North American Indian recognizes footsteps, and can even distinguish between the treads of friends and foes; whilst his white companion, who has lived among the busy hum of cities, is unconscious of the slightest sound. Yet the latter may be a musician, capable of distinguishing the tones of all the different instruments in a large orchestra, of following any one of them through the part which it performs, and of detecting the least discord in the blended effects of the whole,— effects which would be to the unsophisticated Indian but an indistinct mass of sound. In the same manner, a person who has lived much in the country, is able to distinguish the note of

every species of bird that lends its voice to the general charms of nature; whilst the inhabitant of a town hears only a confused assemblage of shrill sounds, which may impart to him a disagreable rather than a pleasurable sensation.

ment.

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To illustrate

Plates of female organs of generation
Kirkes figs 54. 55 & 56.

Generation and Development

The organs and functions which comprise are destined for the propagation of the species, comprise the several provisions made for the formation, impregnation, and development, of the ovum, from which the embryo or foetus is produced & gradually perfected into a living human being.

The organs concerned in effecting these objects are named the generative organs, or sexual apparatus, since part belong to the male and part to the female sex.

Generative Organs of the Female.

The female organs of generation consist of 2 ovaries for the formation of ova; of a Fallopian tube or oviduct, connected with each ovary, for the purpose of conducting the mature ovum to the uterus or cavity in which, if impregnated, it is retained until the embryo is fully developed and fitted to maintain its existence independent of internal connection with the parent; and lastly, of a passage, or vagina, with its appendages for the reception of the male generative organ in the act of copulation.

The ovaries are 2 oval compressed bodies, situated in the cavity of the pelvis, one on each side, enclosed in the folds of the broad ligament. Each ovary is attached to the uterus by a narrow fibrous

cord (the ligament of the ovary), and, more slightly to the Fallopian tube by one of the fimbriae into which the walls of the extremity of the tube expand. The ovary is enveloped by a capsule of dense fibro cellular tissue, which again is surrounded by peritoneum. The internal structure of the organ consists of a peculiar soft fibrous tissue or stroma abundantly supplied with blood vessels, and having imbedded in it, in various stages of development, numerous minute follicles or vesicles, the Graafian vesicles, or cæculi containing the ova. A further account of these vesicles and of their contained ova will be shortly given.

The Fallopian tubes are about 4 inches in length, and extend between the ovaries and the upper angles of the uterus. At the point of attachment to the uterus the Fallopian tube is very narrow, but in its course to the ovary it increases to about a line and a half in thickness; at its distal extremity, which is free and floating, it bears a number of fimbriae, one of which, longer than the rest is attached to the ovary. The canal by which each Fallopian tube is traversed is narrow, especially at its point of entrance into the uterus, at which it will scarcely admit a bristle; its other extremity is wider, and opens into the cavity of the abdomen, surrounded by the zone of fimbriae. Externally, the Fallopian tube is invested with peritoneum; internally, its canal is lined

with mucous membrane covered with ciliary epithelium: between the peritoneal and mucous coat the walls are composed of fibrous tissue similar to that of the uterus.

The uterus is a somewhat pyriform, fibrous organ with a central cavity lined with mucous membrane. In the unimpregnated state it is about 3 inches in length, 2 in breadth at its upper part or fundus but at its lower pointed part or neck only about half an inch. The part between the fundus and neck is termed the body of the uterus: it is about an inch in thickness. The walls of the organ are composed of dense fibro-cellular tissue, which in the unimpregnated state are developed into fibres of organic muscle. The cavity of the uterus corresponds in form to that of the organ itself: it is very small in the unimpregnated state, the sides of its mucous surfaces being almost in contact, and probably only separated from each other by mucus. Into its upper part, at each side, opens the canal of the corresponding Fallopian tube: below it communicates with the vagina by a fissure like opening in its neck, the os uteri, the margins of which are distinguished into 2 lips, an anterior and posterior. At the mucous mem: of the cervix are found several mucous follicles, termed Ovula or glandulae Nabothi: they probably form the jelly like substance by which the os uteri is usually found closed.

The Vagina is a membranous canal, 6 or 8 inches long, extending obliquely downwards and forwards from the neck of the uterus, which it embraces, to the external organs of generation. It is lined with mucous membrane, which in the ordinary contracted state of the canal is thrown into transverse folds. External to the mucous membrane the walls of the vagina are constructed of fibro-cellular tissue, within which, especially around the lower part of the tube, is a layer of erectile tissue. The interior extremity of the vagina is embraced by an orbicular muscle, the constrictor vaginae; its external orifice is, in the virgin, partially closed by a fold or ring of mucous membrane, termed the hymen. The external organs of generation consist of the clitoris, a small elongated body, situated above and in the middle line, and constructed, like the male penis, of 2 erectile corpora cavernosa, and surmounted by an imperforate glans and prepuce; of 2 folds of mucous membrane, termed labia interna or nymphae; and in front of these, 2 other folds, the labia externa or pudenda, formed of the external integument, and lined internally by mucous membrane. Between the nymphae and beneath the clitoris is an angular space, termed the vestibule, at the centre of whose base is the orifice of the meatus urinarius. Numerous mucous follicles are scattered beneath the mucous

membrane, composing these parts of the external organs of generation; and the side of the forepart of the vagina, 2 larger lobulated glands, named vulvo-vaginal, or Duvernoys glands, which are analagous to Cowpers glands in the male.

This is a general outline of the several parts in the female, which contribute to the reproduction of the species. It will now be necessary to examine successively the formation, discharge, impregnation, and development of the ovum, to which these several parts are subservient.

Unimpregnated Ovum.

If the structure and formation of the human ovary be examined at any period between early infancy and advanced age, but especially during that period of life in which the power of conception exists, it will be found to contain on an average from 15 to 20 small vesicles or membranous sacs of various sizes: these have been already alluded to as the follicles or vesicles of De Graaf, the anatomist who first accurately described them. At their first formation, the Graafian vesicles are small, and deeply seated in the substance of the ovary; but as they increase in size, they make their way towards the surface; and when mature they form little prominences on the exterior of the ovary covered only by peritoneum. Each

follicle is formed with an external membranous envelope composed of fine fibro-cellular tissue, and connected with the surrounding stroma of the ovary by a network of blood vessels. (fig 54 Kiloes)
This envelope or tunic is lined with a layer of nucleated cells, forming a kind of epithelium or internal tunic, and named membrana granulosa. The cavity of the follicle is filled with an albuminous fluid in which microscopic granules float; & it contains also the ovum or ovule. The ovum is a minute spherical body situated, in immature follicles, near their centre; but in those nearer maturity, in contact with the membrana granulosa, at that part of the follicle which forms a prominence on the surface of the ovary. The cells of the membrana granulosa are at that point more numerous than elsewhere, and are heaped around the ovum forming a kind of granular zone, the discus proligerus. (fig 54 Kiloes 7)

In order to examine an ovum, one of the Graafian vesicles, it matters not whether it be of small size or arrived at maturity, should be pricked and the contained fluid received upon a piece of glass. The ovum then, being found in the midst of the fluid by means of a simple lens, may be further examined with higher microscopic powers. Owing to its globular form, however, its structure cannot be seen until it is subjected to gentle pressure.

The human ovum is extremely small, measuring, according to Bischoff, from 1/240 to 1/120 of an inch. Its external investment is a transparent membrane, about 1/2500 of an inch in thickness, which, under the microscope, appears as a bright ring (fig 58), bounded externally and internally by a dark outline: it is called the zona pellucida, or vitelline membrane, and corresponds with the chorion of the impregnated ovum. It adheres externally to the heap of cells constituting the discus proligerus.

Within this transparent investment or zona pellucida, and usually in close contact with it, lies the yelk or vitellus, which is composed of granules and globules of various sizes, imbedded in a more or less fluid substance. The smaller granules, which are the most numerous, resemble in their appearance as well as their constant motion, pigment granules. The larger granules or globules, which have the aspect of fat globules, are in greatest number at the periphery of the yelk. The number of the granules is, according to Bischoff, greatest in the ova of carnivorous animals. In the human ovum their quantity is comparatively small.

The substance that combines the globules and granules of the yelk, is in many animals quite fluid. The yelk then completely fills the cavity of the zona pellucida, and escapes in a

liquid form when that membrane is ruptured: but in ova of the human subject and some other animals the yelk is much more consistent, and sometimes escapes as a solid globular mass when the zona pellucida is torn. It is, according to Bischoff, solely owing to this firm consistence of the yelk that it, in many cases, preserves its form when a watery fluid passes by imbibition through the zona pellucida, and that an interval is then apparent between the yelk and that membrane.

In the substance of the yelk is imbedded the germinal vesicle, or vesicula germinativa (figs 55. 56). This vesicle is of greatest relative size in the smallest ova, and is in them surrounded closely by the yelk, nearly in the centre of which it lies. During the development of the ovum, the germinal vesicle increases in size much less rapidly than the yelk, and comes to be placed near to its surface. In a mature ovum of the rabbit it is about 1/60th of a line in diameter (Bischoff); its size in the human ovum has not yet been ascertained, owing to the difficulty of isolating it. It consists of a fine, transparent, structureless membrane, containing a clear watery fluid, in which are sometimes a few granules.

At that part of the periphery of the

germinal vesicle which is nearest to the periphery of the yelk is situated the germinal spot, a finely granulated substance, of a yellowish colour, strongly refracting the rays of light, and measuring, in the Mammalia generally, from $\frac{1}{3600}$ to $\frac{1}{2400}$ of an inch (Wagner).

Such are the parts of which the Graafian follicle and its contents, including the ovum, are composed. This diagram represents them in their relative positions when mature. (Fig 56.)

The questions, 1 whether the Graafian vesicle is the immediate formative organ of the ovum; 2. in what order the several parts of the ovum are formed; 3. and the changes which they undergo in the progress of the ovum to maturity, require consideration.

The first question may be answered in the affirmative, for the researches of Valentin & Bischoff have shown that the Graafian vesicle is formed previous to the ovum, which is subsequently developed in it. Bischoff and Barry agree that the development of the Graafian vesicles and ova continues uninterruptedly from birth to the end of the fruitful period of women's life. In some animals as the cow and sow, it commences in the embryo, even at an early period of uterine existence, but in the dog and rabbit not till after birth. Bischoff describes the process of formation of the Graafian vesicles and ova to be as follows:—

At first nothing can be distinguished in the substance of the ovary but primary cells and nuclei of cells; then round groups of similar cells are seen scattered in large numbers through the stroma. The peripheral cells of each of these groups subsequently coalesce, so as to form a homogeneous transparent vesicular membrane, while the portion of the mass within becomes fluid. Thus is formed a Graafian vesicle. On the inner wall of this follicle or vesicle new cells are formed in the manner of an epithelial layer, while the cavity is found to contain a transparent fluid with nuclei of cells and granules, exactly resembling yelk-granules suspended in it. The next stage is marked by the appearance of a second smaller transparent vesicle within the Graafian vesicle. This second vesicle, which is the germinal vesicle, has a nucleus, the germinal spot. Granules, similar to yelk-granules, soon accumulate around the germinal vesicle; but the further steps in the development of the ovum could not be traced. All its parts were completely formed when Bischoff next observed it.

With regard to the parts of the ovum first formed it appears certain that the formation of the germinal vesicle precedes that of the yelk and zona pellucida, or vitelline membrane. Whether the germinal spot is formed first, and the germinal vesicle afterwards

developed around it, cannot be decided in the case of vertebrate animals; but some recent observations of Kolliker and Bagge on the development of the ova of intestinal worms shew that in these animals, the first step in the process is the production of round bodies resembling the germinal spots of ova, the germinal vesicles being subsequently developed around these in the form of transparent membranous cells.

The more important changes that take place in the ovum subsequent to the formation of these, its essential component parts, consist in alterations of the size and position of these parts with relation to each other, and of the ovum itself with relation to the Graafian vesicle, and in the more complete elaboration of the yelk. The earlier the stage of development the larger is the germinal vesicle in relation to the whole ovum, and the ovum in relation to the Graafian vesicle. For, as the ovum becomes mature, although all these parts increase in size, the Graafian vesicle enlarges most, and the germinal vesicle least. Changes take place also in the position of the parts. The ovum at first occupies the centre of the Graafian vesicle, but subsequently is removed to the periphery. The germinal vesicle too, which in young ova is in the centre of the yelk, is in mature ova found at the periphery.

According to Bischoff, the number of the granules of the yelk is greater the more mature

te ovum, consequently the yelk is more opaque in the mature, and more transparent in the immature ova. The matter in which the granules are contained is fluid in the immature ova of all animals; in some it remains so; but in others, as the human ovum it subsequently becomes a consistent gelatinous substance.

From the earliest infancy and through the whole fruitful period of life there appears to be a constant formation, development, and maturation of Graafian vesicles with their contained ova. Until the period of puberty, however, the process is comparatively inactive, for, previous to this period, the ovaries are small and pale, the Graafian vesicles in them are very minute, few in number, and probably never attain full development, but soon shrivel and disappear instead of bursting as matured follicles do; the contained ova are also incapable of being impregnated. But coincident with the other changes which occur in the body at the time of puberty, the ovaries enlarge, and become very vascular, the formation of Graafian vesicles is more abundant, the size & degree of development attained by them are greater, & the ova are capable of being fecundated.

Discharge of the Ovum.

In the process of development of individual vesicles, it has been already observed that as each increases in size it gradually approaches the surface of the ovary, and when fully ripe or mature,

forms a little projection on the exterior. Coincident with the increase in size caused by the augmentation of its liquid contents, the external envelope of the distended vesicle becomes very thin and eventually bursts. By this means the ovum and fluid contents of the Graafian vesicle are liberated & escape on the exterior of the ovary, whence they pass into the Fallopian tube, the fimbriated processes of the extremity of which are supposed coincidently to grasp the ovary, while the aperture of the tube is applied to the part corresponding to the matured and bursting vesicle.

In animals whose capability of being impregnated occurs at regular periods, as in the human subject, and most Mammalia, the Graafian vesicles and their contained ova appear to arrive at maturity, and the latter to be discharged, at such periods only. But in other animals, e.g. the common fowl, the formation, maturation, and discharge of ova appears to take place almost constantly.

It has long been known that in the so-called oviparous animals the separation of ova from the ovary may take place independently of impregnation by the male, or even of sexual union. And it is now established, especially by the labours of Bischoff, Raciborski & Pouchet that a like maturation and discharge of ova, independently of coition, occurs in Mammalia, and most probably also in the human subject.

the periods at which the matured ova are separated from the ovaries and received into the Fallopian tubes being indicated, in mammalia, by the phenomena of heat or rut; in the human female by the phenomena of menstruation. Sexual desire manifests itself in the human female with greater intensity at these periods, and in the females of mammiferous animals at no other time. If the union of the sexes takes place, the ovum may be fecundated, but if no union occurs it perishes.

In proof that the phenomena of heat in mammiferous animals are coincident with the discharge of ova from the ovaries, independent of the influence of the male, abundant evidence has been collected. Thus Blundell, Haussmann and Bischoff observed that when one oviduct or one half of the uterus had been tied or divided in an animal previous to coitus, although foetuses are subsequently met with only on that side on which the passage to and from the ovary remains free, yet ruptured ovarian vesicles or corpora lutea, are found in both ovaries. And Dr Blundell has shewn that the result, as regards the ovaries, is the same, if the vagina be divided near to the mouth of the uterus, so as completely to interrupt its canal, and to prevent the seminal fluid from reaching even the uterus; although, of course, no embryos are produced in this case. These experiments

proved that Graafian vesicles burst independently of the contact of the seminal fluid; but still they left room for the objection that the rupture of the vesicles might have been caused by the excitement attending sexual connection. This objection, however, is removed by the fact observed by many physiologists, that if mammiferous animals, which have been kept separate from the male, be killed during the period of heat, the Graafian vesicles will be found either turgid and extremely vascular, or already burst: and still more completely by the investigations of Bischoff and Raciborski, who have demonstrated the discharge of ova in the ovaries, although no sexual union had taken place.

Thus to mention one among several conclusive observations, Bischoff having remarked that a large bitch in his possession commenced to be in heat on the 18th & 19th of December, kept her closely shut up, and on the 23rd (having previously on the 21st, ascertained that she was disposed to receive the male, though he did not permit coitus to take place), he cut out the left ovary and Fallopian tube, and closed the wound by suture. On examining the ovary, he found that no Graafian vesicles had yet opened, though 4 of them were much smaller, undergoing the changes preparatory to the discharge of the ova. 8 days later he killed the animal, and found that rupture of the follicles in the

remaining right ovary had taken place: and on examining the Fallopian tube, he found the 4 extruded ova close together, at a distance of about 3 inches down the tube.

It is certain, then, that in mammiferous animals, as in the lower classes, ova are brought to maturity and discharged from the ovaries independently of sexual union. That this maturation and discharge occur periodically, and only during the phenomena of heat, is made probable by the facts that, in all the instances in which Graafian vesicles have been found presenting the appearance of recent rupture, the animals were at the time or had recently been in heat; that, on the other hand, there is no authentic and detailed account of Graafian vesicles being found ruptured in the intervals of the periods of heat; and that female animals do not admit the males, and never become impregnated, except at those periods.

Many circumstances make it probable that the human female is subject, in these respects, to the same law as the females of other mammiferous animals; namely, that in her as in them ova are matured & discharged from the ovary independent of sexual union, and that this maturation and discharge occur periodically at the epochs of menstruation. Thus Graafian vesicles recently ruptured have been frequently seen in the ovaries of virgins or

women who could not have been recently impregnated; and although it is true that the ova discharged under these circumstances have not hitherto been discovered in the Fallopian tube, partly on account of their minute size, and partly because the search has seldom been prosecuted with much care; yet analogy forbids us to doubt that in the human female, as in the domestic quadrupeds, the result and purpose of the rupture of the follicles is the discharge of the ova.

The evidence of the periodical discharge of ova at the epochs of menstruation is first, that nearly all authors who have touched on the point, agree that no traces of follicles having burst are ever seen in the ovaries before puberty or the first menstruation; secondly, that in all cases in which ovarian follicles have been found burst independently of sexual intercourse, the women were at the time menstruating, or had very recently passed through the menstrual state; thirdly, that, although in women sexual connection is not confined to the periods of menstruation, yet conception is more likely to occur within a few days after the cessation of the menstrual flux than at other times; and, lastly, that the ovaries of the human female become turgid and vascular at the menstrual periods, as those of animals do at the time of heat.

From what has been said, it may, therefore, be concluded, that the 2 states, heat and menstruation, are analogous, and that the ~~essential~~ accompaniment of both is the maturation and extrusion of the ova. In both there is a state of active congestion of the sexual organs, sympathising with the ovaries at the time of the highest degree of development of the Graafian vesicles; and in both the crisis of this state of congestion is attended by a discharge of blood ~~and~~ or mucus, or both, from the external organs of generation.

Menstruation and Male Sexual Functions.

Geo. H. Gibb M.D.

24th January 1852

To illustrate

Microscope with Spermatozoa

drawings & plates showing anatomy of testicle, and its ducts, bladder & vesiculae, prostate & cowpers glands.

Kirkes figs 57. 58 & 59

Ovaries and Carpora lutea from Ramsbotham

a sheet of Horners Anatomy for Spermatozoa

Hassall 160. figs 1 & 4. 116. Lemon.

Menstruation. The occurrence of a menstrual discharge is one of the most prominent indications of the commencement of puberty in the female sex; though its absence even for several years is not necessarily attended with arrest of the other characters of this period of life, or with inaptness for sexual union or incapability of impregnation. The average time of its first appearance in females of this country and others of the same latitude, is from 14 to 15; but is much influenced by the kind of life to which girls are subject, being accelerated by habits of luxury and indolence, and retarded by contrary conditions. On the whole, its appearance is earlier in persons dwelling in warm climates than in those inhabiting colder latitudes; though the extensive investigations of Mr Roberton shew that the influence of temperature on the development of puberty has been exaggerated. Much of the influence attributed to climate appears due to the custom prevalent in many hot countries, as in Hindostan, of giving girls in marriage at a very early age, and inducing sexual excitement previous to the proper menstrual time. The menstrual functions continue through the whole fruitful period of a woman's life, and usually ceases between the 45th and 50th years.

The several menstrual periods occur usually at intervals of a solar month, the duration of each

being from 3 to 6 weeks days. In some women the intervals are as short as 3 weeks, or even less; while in others they are longer than a month. The periodical return is usually attended by pain in the loins, a sense of fatigue in the lower limbs, and other symptoms which are different in different individuals. Menstruation does not usually occur in pregnant women, or in those who are suckling; but instances of its occurrence in both these conditions are by no means rare.

The menstrual discharge consists of blood effused from the inner surface of the uterus, and mixed with mucus from the uterus, vagina, & external parts of the generative apparatus. Being diluted by this admixture, the menstrual blood coagulates less perfectly than ordinary blood; and the frequent acidity of the vaginal mucus tends still further to diminish its coagulability. This has led to the supposition that the menstrual blood contains an unusually small quantity of fibrin or none at all. The blood corpuscles exist in it in their natural state: mixed with them may also be found numerous scales of epithelium derived from the mucous passages along which the discharge flows.

Immediately before as well as subsequent to, the rupture of a Graafian vesicle and the escape of its ovum, certain changes ensue in the interior of the vesicle, which result in the production of a yellowish mass termed a corpus luteum.

When fully formed, the Corpus luteum of mammiferous animals is a roundish solid body, of a yellow or orange colour, and composed of a number of lobules which surround, sometimes a small cavity, but more frequently a small stelliform mass of white substance, from which delicate processes pass as septa between the lobules several. Very often, in the cow and the sheep, there is no white substance in the centre of the Corpus luteum; and the lobules projecting from the opposite walls of the Graafian vesicle appear in a section to be separated by the thinnest possible lamina of semi transparent tissue.

When a Graafian vesicle is about to burst & expel the ovum, it becomes highly vascular and opaque; and immediately before the rupture takes place, its walls appear thickened on their interior by a reddish glutinous or fleshy looking substance. Immediately after the rupture, the inner layer of the wall of the vesicle appears pulpy and flocculent. It is thrown into wrinkles by the contraction of the outer layer, and soon, red fleshy mammillary processes grow from it, and gradually enlarge till they nearly fill the vesicle, and even protrude from the orifice in the external covering of the ovary. Subsequently this orifice closes, but the fleshy growth within still increases during the earlier period of pregnancy, the colour of the substance gradually changing from red to yellow, and its consis-

tunic becoming firmer

(fig 57 Kölliker)

The corpus luteum of the human female differs from that of the domestic quadruped in being of a firmer texture, and having more frequently a persistent cavity at its centre, and in the stelliform cicatrix, which remains in the cases where the cavity is obliterated, being proportionately of much larger bulk. The quantity of yellow substance formed is also much less; and although the deposit increases after the vesicle has burst, yet it does not usually form mammiliary granules projecting into the cavity of the vesicle, and never protrudes from the orifice, as is the case in other mammalia. It maintains the character of a uniform, or nearly uniform layer, which is thrown into wrinkles in consequence of the contraction of the external tunic of the vesicle. After the orifice of the vesicle has closed, the growth of the yellow substance continues during the first half of pregnancy, till the cavity is reduced to a comparatively small size, or is obliterated; in the latter case, merely a white stelliform cicatrix remains in the centre of the corpus luteum.

An effusion of blood generally takes place into the cavity of the Graafian vesicle at the time of its rupture, especially in the human subject; but it has no share in forming the yellow body; it gradually loses its colouring matter, and acquires the character of a mass of fibrine.

The serum of the blood sometimes remains included within a cavity in the centre of the coagulum, & then the decolarized fibrine forms a membraniform sac lining the corpus luteum. at other times the serum is removed, and the fibrine constitutes a solid stelliform mass.

The yellow substance of which the corpus luteum consists, both in the human subject and in the domestic animals, is a growth from the inner surface of the Graafian vesicle, the result of an increased development of the cells forming the membrana granulosa which naturally lines the internal tunic of the vesicle.

The first changes of the internal coat of the Graafian vesicle in the process of formation of a corpus luteum, seem to occur in every case in which an ovum escapes; as well as in the human subject as in the domestic quadrupeds. If the ovum is impregnated, the growth of the yellow substance goes on during nearly the whole period of gestation, and forms the large corpus luteum commonly described as a characteristic mark of impregnation. If the ovum is not impregnated, the growth of yellow substance on the internal surface of the vesicle proceeds, in the human ovary, no further than the formation of a thin layer, which shortly disappears; but in the domestic animals it continues for some time after the

ovum has perished, and forms a corpus luteum of considerable size. The fact that a structure, in its essential characters similar to, though smaller than, a corpus luteum, observed during pregnancy, is formed in the human subject independent of impregnation or of sexual union coupled with the varieties in size of corpora lutea formed during pregnancy, necessarily renders unsafe all evidence of previous impregnation founded on the existence of a corpus luteum in the ovary.

Impregnation of the Ovum

Male Sexual Functions

The fluid of the male, by which the ovum is impregnated, consists essentially of the semen secreted by the testicles; and, to this are added as necessary, perhaps, to its perfection, a material secreted by the vesiculae seminales, in which, as in reservoirs, the semen lies before its discharge, and the secretion of the prostate gland, and of Cowpers glands. Portions of these seminal fluids are probably, all discharged together with the proper secretion of the testicles.

The secreting structure of the testicle is disposed in 2 contiguous parts — the body of the testicle, and the epididymis, enclosed within a tough fibrous

membrane, the tunica albuginea. The vas deferens, the main trunk of the secreting tubes, passing to the lower part of the epididymis, assume there a much less diameter, with a very tortuous course: with its various convolutions it forms first the mass named caput minor, then the body, and then the caput major of the epididymus. At the last named part the duct divides into 12 or 12 small branches, the convolutions of which form conical masses, named coni vasculosi, and the vessels continued from these, after anastomoses in what is called the rete testis, lead finally to the tubules which form the proper substance of the testicle, wherein they are arranged in lobules, closely packed, and all attached to the tough fibrous tissue at the back of the testicle.

The tubes, seminal tubes, or tubuli seminiferi, which compose the proper substance of the testicle, are fine thread like tubules, formed of simple homogeneous membrane, measuring on an average from $\frac{1}{100}$th to $\frac{1}{200}$th of an inch, and lined with epithelium or gland cells. They rarely branch, extend as simple tubes through a great length, with the same uniform structure, and probably terminate in loops. Their walls are covered with fine capillary blood-vessels, through which, reckoning their great extent in comparison with the size of the spermatic artery, the blood must move very slowly.

The seminal fluid secreted by the testicle is one of those secretions in which a process of development is continued after its formation by the

secreting

cells, and its discharge from them into the tubes.

The principal part of this development consists in the formation of the peculiar bodies named seminal filaments, spermatozoa, or spermatozoids; the complete development of which, in their full proportion of number, is not achieved till the semen has reached, or has for some time lain in, the vesiculae seminales. Show figures of - Kölliker &c - if possible the Microscope.

Earlier after its secretion first the semen contains none of these bodies, but granules and round corpuscles (seminal corpuscles), like large nuclei, enclosed within parent cells. Within each of these corpuscles, or nuclei, a seminal filament is developed, by a similar process in nearly all animals. Each corpuscle or nucleus, is filled with granular matter; this is gradually converted into a spermatozoid, which is at first coiled up, and in contact with the inner surface of the wall of the corpuscle. (fig 59)

The appearance of the spermatozoids united in fasciculi, which prevails perhaps in all animals, is not owing to their mode of development, but to their tendency, when set free from their formative cells or nuclei, to arrange themselves thus: a tendency showing that their bodies attract each other in the same way that blood disks do in the formation of rouleaux. The fasciculi are formed within the parent cell, when this remains entire after the nuclei or cellules are dissolved; in other cases they are formed in the seminal fluid by the

union of spermatozoids which have been actually seen by the solution of both parent cell & nuclei.

Thus developed, the human seminal filaments consist of a long, slender, tapering portion, called their body or tail, to distinguish it from the head an oval or lyriform portion of larger diameter, flattened and sometimes pointed. They are from 500 to 600 of an inch in length, the length of the head alone being from 5000 to 6000 of an inch, & its width about half as much. View figures.

They present no trace of structure, or dissimilar organs: a dark spot often observed in the head is, probably due to its being concave like a broad corpuscle &c. They move about in the fluid like so many minute corpuscles with each a ciliary process, lashing their tails, and propelling their heads forwards in various lines. Their movement, which is probably essentially, as well as apparently, similar to that of ciliary processes, appears nearly independent of external conditions, provided the natural density of the fluid is preserved; by disturbing this condition, by either evaporating the semen or diluting it, quickly stops the movement. It may continue within the body of the female for 7 or 8 days, and out of the body for at least 24 hours.

The direction of the movement is quite uncertain; but in general, the current that each excites keeps it from the contact of others. The rate of motion, according to Valentin is about 1 inch in 13 minutes.

Respecting the purpose served by these seminal filaments little that is certain can be said. Their occurrence in the impregnating fluid of nearly all classes of animals proves their essentiality to the process of impregnation. They have been sometimes regarded as highly organized and as, in some sense or other, the materials or organs out of which the new individual is begun; by others they are considered as a kind of parasitic animalcules. But probably, all such theories of them are erroneous. Their mode of structure, and their development in cells, not by generation or succession, are inconsistent with the notion of their being, in any sense, distinct animals; neither is there evidence for believing that their entire substance is employed in the construction of the embryo. It is not safe to assume more than that they, like the blood corpuscles, and the corpuscles of other secretions, elaborate the fluid in which they are placed, while themselves undergoing development and growing; that they may therefore be regarded as a kind of floating gland-corpuscles.

And probably they add to this function, that of assisting in the conveyance of the seminal fluid to the ovum; for they have been found sometime after the copulation of dogs and rabbits, covering the surface of the ovum in even the farthest part of the Fallopian tube; and where ever they are, they must carry with them some

of the other constituents of the seminal fluid. So that they may be regarded as conveyors, as well as elaborators of the seminal fluid. Whether their contact with the ovum be essential to its impregnation cannot be determined; it probably is so, though the statements respecting the insertion of part of the seminal filament into the cavity of the ovum have not been confirmed.

The seminal fluid, is probably, after the period of puberty, secreted constantly, though except under excitement, very slowly, in the tubules of the testicles. From these it passes along the vasa deferentia into the vesiculae seminales whence, if not expelled in emission, it may be discharged, as slowly as it enters them, either with the urine which may remove minute quantities mingled with the mucus of the bladder and the secretion of the prostate, or from the urethra in the act of defecation.

The vesiculae seminales have the appearance of out growths from the vasa deferentia. Each of these ducts, just before it enters the prostate gland, through part of which it passes to terminate in the urethra, gives off a side branch, which bends back from it at an acute angle; and this branch dilating, variously branching, and pursuing in both itself and its branches a tortuous course, constructs the vesicula seminalis. Each of the vesiculae, therefore, might be

unravelled into a single branching tube, sacculated, convoluted, and folded up.

The mucous membrane lining the vesiculae seminales, like that of the gall-bladder, is minutely wrinkled and set with folds and ridges arranged so as to give it a finely reticulated appearance. The rest of their walls is formed, chiefly, of a layer of organic muscular fibres, from which they derive contractile power for the expulsion of their contents.

To the vesiculae seminales a double function may be assigned; for they both secrete some fluid to be added to that of the testicles, and serve as reservoirs for the seminal fluid. The former is their most constant and probably most important office; for in the horse, bear, guinea pig, and several other animals, in whom the vesiculae seminales are large and of apparently active function, they do not communicate with the vasa deferentia, but pour their secretions separately, though it may be simultaneously into the urethra. In man, also, when one testicle is lost, the corresponding vesicula seminalis suffers no atrophy, though its function as a reservoir is abrogated. But how the vesiculae seminales act as secreting organs is unknown; the peculiar brownish fluid which they contain after death does not properly represent their secretion, for it is different

in appearance from anything discharged during life, and is mixed with semen. It is nearly certain however that their secretion contributes to the proper composition of the impregnating fluid; for in all the animals in whom they exist, & in whom the generative functions are exercised only once at one season of the year, the vesicula seminales whether they communicate with the vasa deferentia or not, enlarge commensurately with the testicles at the approach of that season. That the vesiculae are also reservoirs in which the seminal fluid may lie for a time previous to its discharge, is shewn by their commonly containing the seminal filaments in larger abundance than any portion of the seminal ducts themselves do. The fluid like mucus, also which is often discharged from the vesiculae in straining during defecation, commonly contains seminal filaments. But no reason can be given why this office of the vesiculae should not be equally necessary to all the animals whose testicles are organized like those of man, or why in many animals the vesiculae are wholly absent.

There is an equally complete want of information respecting the secretions of the prostate and Cowpers glands, their nature, and purposes. That they contribute to the right composition of the impregnating fluid, is shewn both by the position of the glands, and by their enlarging

with the testicles at the approach of the animals breeding time. But that they contribute only a subordinate part, is shewn by the fact that when the testicles are lost, though these organs be perfect, all procreative power ceases.

The mingled secretions of all the organs just described form the Semen, or seminal fluid. Its corpuscles are already described: its fluid part has not been satisfactorily analysed; but Henle says it contains fibrine, because, shortly after being discharged, flocculi form in it by spontaneous coagulation, and leave the rest of it thinner and more liquid, so that the filaments move in it more actively.

Nothing has shewn what it is that makes this fluid capable of impregnating the ovum, or (which is yet more remarkable) of giving to the developing offspring all the characters, in features, size, mental disposition, and liability to disease which belong to the father. This is a fact wholly inexplicable; and is perhaps exceeded in strangeness by none but those which shew that the seminal fluid may exert such an influence, not only on the ovum which it impregnates, but on many which are subsequently impregnated by the seminal fluid of another male. It has been often observed for example that a well-bred bitch, if she have been once impregnated by a mongrel dog, will not bear thorough-bred puppies in the next 2 or 3 litters after that succeeding the

copulation with the Mongrel. But the best instance of this kind was in the case of a mare belonging to Lord Ellesmere, who, while he was in India, and wished to obtain a cross-bred between the horse and quagga, caused this mare to be covered by a male quagga. The foal that she next bare had distinct marks of the quagga, in the shape of its head, black bars on the legs and shoulders and other characters. After this time she was thrice covered by horses, and every time she bare the foal had still distinct, though decreasing, marks of the quagga; the single impregnation by the seminal fluid of the quagga had impressed its character not only on the ovum then impregnated, but on the 3 following ova impregnated by horses.

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Development of Ovum & Embryo.

Geo. R. Gibb M.D

30th January 1852

To illustrate

Kirbies - plates nicely drawn on uniform sheets
figs 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72
Hassall plate X
Specimens of ova, shaggy carion
Tennents Carpenter - diam figs 102. 103.
Mueller fig 163. drawing page 159
Ova. Med & Phy Dicy - Frontispiece -

Development.

Changes in the Ovum previous to the Formation of the Embryo.

Of the changes which the ovum undergoes previous to the formation of the embryo, some occur while it is still in the ovary, and apparently are independent of impregnation; others take place after it has reached the Fallopian tube. The knowledge we possess of these changes is derived almost exclusively from observations on the ova of mammiferous animals, especially the bitch and rabbit; but it may be inferred that analogous changes occur in the human ovum.

Beischoff describes the yelk of an ovarian ovum after coitus as being unchanged in its characters, with the single exception of being fuller and more dense: it is still granular, as before, and does not possess any of the cells subsequently found in it. The germinal vesicle always disappears, sometimes before the ovum leaves the ovary, at other times not until it has entered the Fallopian tube; but always before the commencement of the metamorphosis of the yelk. Of the manner in which the germinal vesicle, & with it the germinal spot, disappears, and of the changes which they are supposed previously to undergo, much has been written, though little is with certainty known.

The cells of the membrana granulosa, which

immediately surround and adhere to the ovum, undergo a peculiar change of form about the time at which the ovum is destined to leave the ovary. They become club-shaped, their pointed extremities being attached to the zona pellucida, so as to give the ovum a stellate appearance; (fig 60. B Kölliker). When the ovum enters the Fallopian tube, these cells lose their spindle or club like shape and become quite round. In the latter, they continue to invest the ovum in this round shape throughout the whole tract of the Fallopian tube, disappearing only when the ovum reaches the uterus; but, in the rabbit they wholly disappear at its very commencement.

Besides the disappearance of the germinal vesicle, and, in the rabbit, the disappearance also of the cells of the membrana granulosa, the yelk, in the upper part of the Fallopian tube, no longer completely fills the zona pellucida, but contracts, and leaves a clear space between them.

As the ovum approaches the middle of the Fallopian tube, it begins to receive a new investment, consisting of a layer of transparent albuminous or glutinous substance, which forms upon the exterior of the zona pellucida. It is at first exceedingly fine, and, owing to this, and to its transparency, is not easily recognised; but at the lower part of the Fallopian tube it acquires

considerable thickness, and shortly begins to assume the character of the chorion, into which it, together with the zona pellucida, is subsequently converted. At this part of its transit along the Fallopian tube, the ovum still remains unchanged in structure, and no alteration, beyond increased thickness, is perceived in the zona pellucida. A remarkable phenomenon has, however, been noticed by Bischoff in the rabbit, about this time, named the performance of the entire yelk of regular and energetic movements rotatory within the zona pellucida; a phenomenon produced he says, by the action of vibratile cilia situated upon the surface of the yelk.

The changes which the mammalian ovum undergoes in its passage through the second half of the Fallopian tube, consist in the further formation of the chorion, and in the peculiar process of cleaving, or division and subdivision, of the substance of the yelk, which will now be described.

Bischoff, whose observations were made on rabbits and bitches, states that, when the ovum has passed the middle of the Fallopian tube in its transit to the uterus, the yelk, which was previously one compact uniform mass, begins to ~~become~~ be resolved into a number of smaller spheroidal masses; first into 2, then into 4, then 8, then 16, and so on. (see fig 61 of Kölles.)

Each segment contains a transparent vesicle, like an oil globule, which is seen with difficulty, especially in the bitch's ovum, on account of its being developed by the yelk granules, which adhere closely to its surface. He has not been able to detect a nucleus in it, and therefore does not regard it as a true cell. Neither does he regard the globular segments themselves as cells, for neither in the rabbit nor in the bitch can any investing membrane be discerned: they seem to be mere aggregations of yelk substance around the central body or vesicle.

The process is closely identical with changes which ensue in the ova of certain species of Ascaris, except that, in the latter case, they result from the division and subdivision of nucleated cells, which, like the oil-like vesicles in the Mammalian ovum, attract around them certain portions of the substance of the yelk. (See fig 62. Kölen.)

About the time at which the Mammiferous ovum reaches the uterus, the process of division and subdivision of the yelk appears to have ceased, its substance having been reduced into its ultimate and smallest divisions, while its surface presents a uniform finely granular aspect, instead of its late mulberry-like appearance. The ovum, indeed, appears at first sight to have lost all trace of the cleaving process, and, with the exception of

being paler and more translucent, almost exactly resembles the ovarian ovum; its yelk consisting apparently of a confused mass of finely granular substance. But on more careful examination it is found that these granules are aggregated into numerous minute spherical masses, each of which contains a clear vesicle in its centre, but is not, at this period, provided with an enveloping membrane, and possesses none of the other characters of a cell. The Zona pellucida, and (in the rabbit) the layer of albuminous matter surrounding it, have at this time the same characters as when at the lower part of the Fallopian tube.

Shortly after this important changes ensue. Each of the several globular segments of the yelk becomes surrounded by a membrane, & is thus converted into a cell, the nucleus of which is formed by the central vesicle, the contents ~~of~~ by the granular matter originally composing the globules; these granules usually arrange themselves concentrically around the nucleus. When the peripheral cells, which are formed first, are fully developed, they arrange themselves at the surface of the yelk into a kind of membrane, and at the same time assume a pentagonal or hexagonal shape from mutual pressure, so as to resemble pavement-epithelium. As the globular masses of the interior are gradually converted into cells, they also pass to the surface

and accumulate there, thus increasing the thickness of the membrane already formed by the more superficial layer of cells, while the central part of the yelk remains filled only with a clear fluid. By this means the yelk is shortly converted into a kind of secondary vesicle, situated within the zona pellucida, and named by Bischoff, vesicula blastodermica.

The vesicula blastodermica, or germinal membrane as it is also called, shortly undergoes a rapid increase in extent and thickness; its growth being effected apparently by the development of new cells, the mode of origin of which is obscure. Within the substance of the germinal membrane shortly appears the first trace of the embryo.

The time occupied in the passage of the ovum, from the ovary to the uterus, occupies, according to Bischoff, 3 days in the rabbit, 4 or 5 days in ruminants, and probably, 8 or 10 in the human female. Bischoff, also believes that the ovum escapes from the Graafian vesicle at the time when the menstrual discharge is about to cease; and since, if not fecundated, it probably always perishes when it arrives at the lower part of the Fallopian tube, or at any rate, at the uterus, he infers that sexual connection, to be fruitful in the human subject, must take place within 8 or 10 days from the cessation of the menstrual discharge. Raciborski thinks the time even

more limited than this; but he states that im-
pregnation may also result from sexual union
taking place one or 2 days before the commence-
ment of the period of menstruation.

Changes of the Ovum within the Uterus.

It has been remarked that in its passage along
the Fallopian tube the ovum is invested externally
with a layer of albuminous substance. In birds,
the quantity of this albuminous coating is very large,
and constitutes what is termed the white of the
egg; it serves for the nourishment of the embryo
until the chick is fully developed, and ready to
maintain its existence out of the shell.
Mammiferous ova do not require any such
large store of nutriment, for when they reach
the uterus they enter into such intimate connec-
tion with it, by means of structures presently
to be described, that their means of subsistence
and growth are derived entirely from the parent.

The exterior of the mammiferous ovum, there-
fore, acquires only a thin layer of albuminous
substance. This shortly becomes intimately u-
nited with the zona pellucida, together with
which it forms a membrane termed the cho-
rion. Shortly after its formation, the Chorion
sends off from its external surface numerous
villous processes, which give it a shaggy or
spongy appearance, and which appear to be destined

for the absorption of nutriment from the internal surface of the uterus during the earliest period of embryonic life.

Before the impregnated ovum reaches the uterus, certain preparations are made in that cavity for its reception. These changes consist especially in an increased development of the sexual part composing the mucous membrane of the uterus, which results in the formation of the membrana decidua — so called on account of being discharged from the uterus at parturition. The mucous membrane of the human uterus is abundantly beset with tubular follicles, arranged perpendicularly to the surface. These follicles have not been described as existing in the unimpregnated uterus; but, their appearance immediately after impregnation, and the existence of follicles in the unimpregnated uterus of the bitch, and other animals, leave little doubt of their entering into the structure of the mucous membrane of the human uterus previous to impregnation. Examined shortly after impregnation, these glands are found elongated, enlarged, and much waved and contorted towards their deep and closed extremity, which is implanted at some depth in the tissue of the uterus, and commonly dilates into 2 or 3 closed caeculi. (fig 63 Kiles)

On the internal surface of the mucous membrane

* Fig 102 shows Fenwicks Carpenter—

may be seen the circular orifices of the glands, many of which are, in the early period of pregnancy, surrounded by a whitish ring, formed of the epithelium which lines the follicles. (fig 64 Kiles)

Coincidently with the increasing size of the follicle, the quantity of their secretion is augmented, the vessels of the mucous membrane become larger and more numerous, while a substance composed chiefly of nucleated cells fills up the interfollicular spaces in which the blood vessels are contained. The effect of these changes is an increased thickness, softness, and vascularity, of the mucous membrane, which itself forms the membrana decidua.

The object of this increased development seems to be the production of nutritive materials for the ovum; for the cavity of the uterus shortly becomes filled with secreted fluid, consisting almost entirely of nucleated cells, in which the villi of the chorion are imbedded. The villi of the chorion do not seem to have been traced into the follicles, although Bischoff thinks it probable that they do enter them. But in the bitch they may be easily traced into the dilated glands of the mucous membrane. According to Sharpey, the glands of the mucous membrane of the bitches uterus are of 2 kinds, simple and compound. The former, which are the more numerous, are merely very short unbranched tubes closed at one end

(fig 65 Kirkes 1. 1.); the latter (2, 2) have a long duct dividing into convoluted branches; both open on the inner surface of the membrane by small round orifices, lined with epithelium, and set closely together. After impregnation, the glands of those parts of the mucous membrane which come into immediate relation with the ova greatly enlarge; while the extremity of each compound gland, just before it opens on the surface of the uterus, dilates into a pouch, or cell, filled with whitish secretion, within which is received a process of the chorion. The simple glands also dilate and receive each a foetal villus.

When the ovum enters the uterus, it becomes imbedded in the structure of the decidua which is yet quite soft. The earliest ova which have been observed in connection with the decidua, were not contained free in its cavity, but appeared to be implanted in it or pressed into it from without; the decidua, at the point of entrance of the ovum, being protruded inwards, and the ovum contained in a hollow of its external surface. During the further growth of the ovum, the decidua becomes more and more inverted at this point, the inverted part being received into the cavity of the rest of the membrane. This inverted portion is called the decidua reflexa, while the other

shown fig 103 Fenwicks Carpenter -

part of this membrane is called the decidua vera. At the part where the uterine expansion of the decidua is interrupted by the reflexion inwards of the of the decidua reflexa, and where the ovum entered, the place of the decidua vera is supplied by another layer similar to it, and connected at its margins with it, the "decidua serotina."

When young ova are examined in the uterus, both the decidua vera and the decidua reflexa are generally found; but in aborted ova this is seldom the case, a part of the decidua being most frequently retained in the uterus. As the ovum increases in size, the decidua vera and the decidua reflexa gradually come into contact, and in the 3rd month of pregnancy the cavity between them has quite disappeared. Henceforth it is very difficult or even quite impossible, to distinguish the 2 layers.

Development of the Embryo.

We have already traced the changes which ensue in the mammalian ovum subsequent to impregnation, as far as the formation of the germinal membrane which consists of a layer of epithelium-like cells, enclosing the substance of the yelk, and immediately in contact with the internal surface of the Zona pellucida. Most of the subsequent changes which ensue in the formation of the mammalian embryo are similar to those which take place in the development of the chick, and in many

respects similar to those which occur in Amphibia and fishes: and the names applied to the several parts are the same in each case. Hence each step in the process may be illustrated by the results of observations on the development of these lower animals; shown Russell plate X. here.

Very soon after its formation, the germinal membrane presents at one point on its surface an opaque roundish spot, which is produced by an accumulation of cells and nuclei of cells, of less transparency than elsewhere. This space, the "area germinativa" or germinal area, is the part at which the embryo first appears. About the same time the germinal membrane becomes visible, in the direction of its thickness, into 2 distinct laminae. This division is at first most manifest at the situation of the area germinativa, but it soon extends from this point, & implicates nearly the whole of the germinal membrane. The superior or external layer, which lies next to the ~~area~~ zona pellucida, is called the serous layer; from it are developed the organs of the animal system of the body, e.g. the bones, muscles, and integuments: the inferior or internal division, in contact with the yelk itself, is named the mucous layer and serves for the formation of the internal or visceral system of organs.

At its first appearance, the area germinativa has a rounded form, but it soon loses this and becomes oval, then pear-shaped, and while this change in form is taking place,

there gradually appears in its centre a clear space or area pellucida (fig 67, C), bounded externally by a more opaque circle, which subsequently becomes the area vasculosa (B), — so named because of its being the part in which the blood vessels are first formed. In the formation of these 2 spaces both the serous & mucous laminae of the germinal membrane take part. The comparative obscurity of the outer space — the area vasculosa — is due to the greater accumulation of nucleated cells and nuclei at that part than in the area pellucida.

The first trace of the embryo in the centre of the area pellucida consists of a shallow groove or channel, the primitive groove (fig 67, E,) formed in the external or serous fold of the germinal membrane: the mucous fold has no direct share in its production. The groove is wider at its anterior or cephalic extremity, and tapers towards the opposite extremity.

Coincidently with the formation of the primitive groove, 2 oval masses of cells, the lamina dorsales (D) appear, one on each side of the groove. At first scarcely elevated above the plane of the germinal membrane, they soon rise into 2 prominent masses, the upper borders of which gradually tend towards each other, turning inwards over the primitive groove. Their form changes as that of the area pellucida does, passing gradually with the latter from an oval

to a pyriform shape, and eventually becoming guitar-shaped. According to Bischoff the part of the inner side of each of these masses which immediately adjoins the primitive groove, shortly becomes pellucid, and is developed into nervous substance. The parts from opposite sides then unite, and convert the primitive groove into a tube, which is the central canal of the cerebro spinal axis, the surrounding nervous matter constituting the substance of the rudimental spinal cord and brain or cerebral vesicles, which are thus formed the first parts of the embryo that are developed. The shaping out of the 3 cerebral vesicles or divisions of the brain takes place before the primitive groove is closed over; its cephalic extremity dilating into 3 pouches (B fig 68). The opposite or caudal extremity of the groove at the same time dilates into a lancet-shaped pouch (the sinus rhomboidalis), which corresponds to the future cauda equina (C). The closure of the canal by means of the internal nervous sides of the laminae dorsales commences first at the middle, and then gradually proceeds along its whole length: at the same time the other parts of the corresponding laminae dorsales of the opposite sides unite and form the rudiments of the head and dorsal part of the body.

Immediately beneath, and in a line parallel with the primitive groove, may be seen, about the same time, a narrow linear

mass of cells, the chorda dorsalis, which forms the basis around which the vertebral column is developed. The development of this column is early indicated by the appearance of a pair square at first indistinct, plates, the rudiments of vertebrae (fig 68. D), which begin to appear at about the middle of each dorsal lamina.

While the dorsal laminae are closing over the primitive groove, thickened prolongations of the serous layer are given off from the lower margin of each; these are named laminae visceralis seu ventrales. At first the visceral laminae proceed on the same plane with the germinal membrane, but by degrees they bend downwards and inwards towards the cavity of the yelk, where they unite and form the interior walls of the trunk. During these changes an accumulation of cells ensues between the mucous and serous laminae at the part of the germinal membrane already named the area vasculosa. Within this mass, which constitutes a third or middle layer of the germinal membrane, is laid the foundation for the development of the vascular system. At the circumference of the vascular area, insulated red spots and lines make their appearance, and these soon unite so as to form a network of vessels filled with blood. The margin of the vascular layer is at first limited and quite circular, being bounded by vessels united in a circulus venosus,

or sinus terminalis (fig 71), but it soon extends over the whole surface of the germinal membrane.

About the same time the rudimentary heart is formed in the same layer of the germinal membrane, bending downwards from the cephalic portion of the embryo, so as to enclose the anterior part of the cavity of the body. As shewn by Schwann, the blood vessels are developed originally from nucleated cells. These cells send out processes; the processes from different cells unite; and in this way ramifications and a network are produced. Vessels extend from this network in the area vasculosa into the area pellucida, and join the rudimentary heart. It has, at first, the form of a long slightly curved tube, prolonged inferiorly into 2 venous trunks, and superiorly into 3 or more aortic arches on each side. These arches unite beneath the vertebral column, and form the aorta (see fig 71).

The vessels extending from the vascular layer now ramify in the animal, as well as in the organic, system of the embryo, and aid essentially in its further development.

In the primitive state of the embryonic circulation, the aorta divides into a right & a left branch, and these are continued as the arteriae omphalo-mesentericae (a. a. fig 71), into the germinal membrane, where they ramify and anastomose until they reach a circular

venous canal (S) which surrounds the area vasculosa. From this venous canal, the sinus terminalis, and from the vascular network of the germinal membrane, the blood is brought back by the venae omphalo-mesentericae (V. V), which issue from the area vasculosa at points corresponding to the anterior and posterior extremities of the embryo (cuts 71 and 72).

Subsequently other veins are developed in the vascular network, which follow the course of the arteries; and at length the terminal sinus entirely disappears, and the whole yelk sac becomes covered with blood-vessels.

45

Development of Embryo & its Organs.

George Gibbs M.D.

14th February 1852.

To Illustrate

Kirkes. Plates nicely drawn in miscellaneous sheets with others –

Figs 72. 73. 74. 75. 76. 77 double size of these
78. 79. 80. 81. 82.

Figs 84. 86. 87. 91. 92. 93. 94. 95. 96

or

72 Kirkes – see 12 Baly . page 85
73. 74. 75. all in Kirkes.
76 Kirkes see 13. 14. Baly page 87
77 do see 226 Muller " 1590
78 do see 230 do " 1605
79 do see 231 do " 1605
80 do see 232 do " 1606
81 do see 233 do " 1606
82 do see 17 Baly " 95
84 do see 223 Muller " 1588
86 do see 239 do " 1620
87 do see 240 do " 1621
91 do see 24 Baly " 108
92. 93. 94. all in Kirkes
95 Kirkes see 245 Muller " 1634
96 do see 248 do " 1637

Continuation of the Development of the Embryo.

During the primitive changes in the embryonic circulation, described in the concluding part of my last lecture, the embryo together with the immediately contiguous part of the germinal membrane, elevates itself above the level of the rest of that membrane in the form of a small boat (see fig 72), enclosing a cavity open beneath, which is the first condition of the cavity of the trunk of the future animal.

The cephalic end of the embryo, with the anterior part of the body, first bends forwards and downwards, and the germinal membrane follows this depression, producing a fold termed *involucrum capitis*.

Shortly afterwards a similar fold of the germinal membrane is formed at the caudal extremity of the embryo (*vagina caudae*), and presses from behind forwards beneath it (see fig 73).

These 2 folds are connected by that part of the boat shaped embryo which passes off from the structure of the axis on each side into the expanded germinal membrane. In this way the embryo becomes in some measure separated by a constriction, both anteriorly, posteriorly, and at the sides, from the rest of the germinal membrane above the surface of which it elevates itself, with the cavity of its trunk, still in great part open, turned towards the yelk. The part of the internal layer

of the germinal membrane which lines the cavity of the embryo is the primitive form of the intestinal canal. That part of the external layer of the germinal membrane, on the contrary, which descends on each side from the rudimentary axis of the embryo, and con~~stitu~~tributes to its boat like form, is continuous with the rudimentary structures which are destined to form the parietes of the trunk, namely, the walls of the neck, chest, & abdomen.

In a further continuation of the above changes, the cephalic, caudal, and latual edges of the external layer of the germinal membrane rise still more, and extend over the body of the embryo from its abdominal towards its dorsal aspect, where they at length meet and coalesce, enclosing the embryo in a shut sac, the amnion (figs 74 and 75.)

While the inner of the 2 layers of which this fold of the germinal membrane consists, forms the sac of the amnion, the outer lines the internal surface of the zona pellucida, or, as it has now become, the chorion. The lamella forming the amnion is continuous with the skin of the embryo at the former line of union of the parietes of its body with the external layer of the germinal membrane. The parietes of the body of the embryo are therefore reflected upon themselves, as it were, so as to form the membrane of the amnion. The part at which the reflection takes place, is the umbilicus. This at first is wide and long,

but it gradually grows smaller.

The inner layer of the germinal membrane remains continuous with the intestinal cavity. The constricted part at which it is continued into the wall of the intestinal cavity or tube (fig 74 c,) is now called the vitelline duct, ductus vitello-intestinalis, or omphalo-mesenteric duct; the inner layer of the germinal membrane having at this period extended over the whole yelk, and become the vitelline sac, yelk-sac, or, in Mammalia, the umbilical vesicle.

By the constriction which the fold of germinal membrane, in which the abdominal walls are formed, produces at the umbilicus (c'), the body of the embryo becomes in great measure detached from the yelk sac or umbilical vesicle, though the cavity of the rudimentary intestine still communicates with it through the vitelline or omphalo-mesenteric duct, and contains part of the yelk substance with which the vesicle was filled. The yelk-sac contains, however, the greater part of the substance of the yelk, and furnishes a source whence nutriment is derived for the embryo. In birds, the contents of the yelk sac afford nourishment until the end of incubation: but in Mammalia, the office of the corresponding umbilical vesicle ceases at a very early period, the quantity of yelk is small, and the embryo soon becomes independent of it by the connections it forms with the parent. Maroner, in birds, as the sac is emptied it is gradually drawn into the

abdomen through the umbilical opening which then closes over it; but in Mammalia it always remains on the outside, and as it is emptied it contracts, shrivels up, and, with the part of its duct external to the abdomen, is detached and disappears either before or at the termination of intrauterine life, the period of its disappearance varying in different orders of Mammalia.

The walls of the yelk sac are formed by the serous layers of the germinal membrane, of which the mucous and vascular layers become much developed and are actively concerned in the absorption of the contents of the sac. The vessels ramifying in the vascular layer are named, as already said, <u>omphalo-mesenteric</u>: their trunks, an artery and 2 veins, enter the abdomen at the umbilicus with the vitelline or omphalo-mesenteric duct. The mucous surface lining the interior of the sac is, in the chick especially, highly developed, and presents numerous vascular folds or processes for the absorption of the yelk; for the contents of the sac do not pass directly into the intestine, with which at first, through the persistent vitelline duct, the sac communicates, but are absorbed by the omphalo-mesenteric vessels and conveyed to the liver. The vascular folds of the mucous membrane are covered by the granules of the yelk which give them a yellowish colour, and hence led to the vessels being formerly called <u>vasa lutea</u>.

During the formation of the umbilical vesicle a pear-shaped solid mass of cells projects from the interior or caudal extremity of the embryo, and is shortly developed into a vesicle named allantois. It has been said by some to proceed directly from the intestinal canal (as shown in fig 75); by others from the Wolffian bodies or rudimental kidneys; but, at least in the Mammalia, it does not do so, for, as shewn by Bischoff, at the time of its first appearance no trace either of the intestinal canal or of the Wolffian bodies can be perceived. It subsequently, however, communicates with both these parts. As the allantois is developed, its walls become very vascular, containing the ramifications of what become the umbilical arteries and vein. It grows rapidly, and elongates itself until it reaches the chorion, in the villi of which membrane the umbilical vessels are brought into connection with the parent by means of the placenta, presently to be described. In Mammalia, the vessels conveyed by the allantois are distributed only at that part in which the placenta exists; but in birds, the allantois with its vessels envelops the entire embryo; it forms a very vascular layer lining the interior of the egg shell, and affords by this means an extensive surface in which the blood may be aerated. In placental Mammalia the aerating function is discharged by the placenta

As the visceral laminae close in the

abdominal cavity, the allantois is thereby divided at the umbilicus into 2 portions: the larger proceeding with the umbilical vessels to the chorion, while the smaller is retained in the abdomen, and converted into the urinary bladder. These 2 portions are connected together by a constricted part, named the urachus.

The Chorion and Placenta.

The mode in which the human embryo is connected with the uterus, for the purpose of drawing from the parent the supplies of nutriment necessary for its growth and development, must now be considered. It has been already said that during its passage along the Fallopian tube, the ovum acquires a layer of albumen, and that this subsequently coalesces with the zona pellucida to form the chorion on the surface of which little villous processes shortly arise, giving the globular mass containing the ovum a shreddy flocculent appearance.

The villi of the chorion consist at first entirely of cells bounded by an external layer of textureless membrane which gives their form (Goodsir). When the ovum, with its villous chorion, reaches the uterus, the villi become imbedded in the secretion poured forth by the enlarged follicular glands of the mucous membrane of that organ; and from this they doubtless derive the nutriment on which the embryo at first subsists.

Further provision is, however, shortly made for procuring nourishment, by the development of blood vessels within the villi and the junction of these with the branches of the umbilical vessels brought by the allantois to the chorion. The foetal vessels thus come into intimate relation with the vessels of the uterus. The part at which this relation between the vessels of the foetus and those of the parent ensues is not, however, over the whole surface of the chorion; for although all the villi become vascular, yet in the human subject, it is at one part only that they are greatly developed, and by their branching give rise, with the vessels of the uterus, to the formation of the placenta (fig 77).

The ovum appears to have a firm connection with the uterus in all Mammalia, with the exception of the Marsupialia and Monotremata. The means of attachment are always either vascular villi or folds of the chorion. The chorion receives its blood-vessels from the umbilical vessels of the foetus, which are distributed upon the allantois, and by it are conducted to the chorion. The villi are sometimes distributed over the whole surface of the chorion; sometimes they form a zone around the ovum; at other times they are collected into several masses, or cotyledons, scattered over the chorion; and lastly in man and some other animals, they form a single placenta upon one side of the chorion.

The human placenta is composed of two parts,

the placenta foetalis and the placenta uterina, intermingled. The foetal placenta consists entirely of dense tufts of branched vascular villi, whilst the uterine placenta is formed of the substance of the decidua, which receives the villi of the foetal placenta, and completely encloses them.

The ends of the foetal villi contain the inosculating loops of the minute branches of the umbilical arteries and veins of the foetus; each vessel makes several turns from one loop into another before it enters the nearest venous trunk (fig 78 and 79). According to Dr Reid the blood sent from the mother to the placenta is poured by the curling arteries of the uterus (1 fig 80 and fig 81), "into a large sac (3, fig 81), formed by the inner coat of the vascular system of the mother, which is intersected in many thousand different directions by the placental tufts (3 fig 80), projecting into it like fringes, and pushing its thin wall before them in the form of sheaths, which closely envelope both the trunks and each individual branch composing these trunks (fig 81). From this sac the maternal blood is returned by the utero-placental veins (2, fig 81)."

It thus appears that the tufts and villi of the foetal portion of the placenta are completely sheathed by the lining membrane of the vascular system of the mother. It would seem also from the observations of Professor Goodsir, that, at the villi of the placental tufts, where the foetal and

maternal portions of the placenta are brought into close relation with each other, the blood in the vessels of the mother is separated from that in the vessels of the foetus by the intervention of 2 distinct sets of nucleated cells. One of these belongs to the maternal portion of the placenta, is placed between the membrane of the villus and that of the vascular system of the mother, and is probably designed to separate from the blood of the parent the materials destined for the blood of the foetus; the other belongs to the foetal portion of the placenta, is situated between the membrane of the villus and the loop of vessels contained within, and probably serves for the absorption of the material secreted by the other set of cells, and for its conveyance into the blood vessels of the foetus. (See fig 82.)

Between the 2 sets of cells with their investing membrane there exists a space, d, into which it is probable that the materials secreted by the one set of cells of the villus are poured, in order that they may be absorbed by the other set, and thus conveyed into the foetal vessels.

Development of Organs.

It remains now to consider the development of the sexual organs and systems of organs in the further progress of the embryo.

Development of the Vertebral Column & Cranium.

The primitive part of the vertebral column in all the Vertebrata is the gelatinous charda dorsalis, which consists entirely of cells. This cord tapers to a point at the cranial and caudal extremities of the animal. In the progress of its development it is found to become enclosed in a membranous sheath, which at length acquires a fibrous structure, composed of transverse annular fibres. The charda dorsalis is to be regarded as the azygous axis of the spinal column, and in particular of the future bodies of the vertebrae, although it never itself passes into the cartilaginous or the osseous state.

The cartilaginous or osseous vertebrae are always first developed in pairs of lateral elements at the sides of the charda dorsalis. From these lateral elements are formed the bodies and the arches of the vertebrae. Before the disappearance of the charda, the ossification of the bodies and arches of the vertebrae begins at distinct points.

The true cranium is a prolongation of the vertebral column, and is developed at a much earlier period than the facial bones. Originally it is formed of but one mass, a cerebral capsule, the charda dorsalis being continued into its base, and ending there with a tapering point.

Development of the Extremities.

The extremities are developed in an uniform manner in all vertebrate animals. They appear in the form

of leaf-like elevations from the parietes of the trunk (as fig 84), at points where more or less of an arch will be produced for them within. The primitive form of the extremity is nearly the same in all Vertebrata, whether it be destined for swimming, Crawling, walking, or flying. In the human factus the fingers are at first united as if webbed for swimming; but this is to be regarded not so much as an approximation to the form of aquatic animals, as the primitive form of the hand, the individual parts of which subsequently become more completely isolated.

Development of the Vascular System.

The first development of the vascular system & heart in the germinal membrane has been already alluded to. The earliest form of the heart presents itself as a solid compact mass of embryonic cells, similar to those of which the other organs of the body are constituted. It is at first unprovided with a cavity: but this shortly makes its appearance, resulting apparently from the separation from each other of the cells of the central portion. A liquid is now formed in the still closed cavity; and the central cells may be seen floating within it. These contents of the cavity are soon observed to be propelled to and fro with a tolerable degree of regularity, owing to the commencing pulsations of the heart. These

pulsations take place even before the appearance of a cavity, and immediately after the first "laying down" of the cells from which the heart is formed. At first they seldom exceed from 15 to 18 in the minute. The fluid within the cavity of the heart shortly assumes the character of blood. At the same time the cavity itself forms a communication with the great vessels in contact with it, and the cells of which its walls are composed are transformed into fibrous and muscular tissues and into epithelium.

Bloodvessels appear to be developed in 2 ways, according to the size of the vessels. In the formation of large bloodvessels, masses of embryonic cells similar to those from the heart and other structures, are developed, of the embryo, arrange themselves in the position, form, and thickness of the developing vessel. Shortly the cells in the interior of a column of this kind seem to be developed into blood-corpuscles, while the external layer of cells is converted into the walls of the vessel. In the development of capillaries again, arches are formed, from prolongations of both artery and vein, new prolongations are formed, & secondary arches pass from them, and unite together.

About the time that the heart at its lower extremity receives the venous trunks, and at its upper extremity divides into the arterial trunks or aortic arches, it becomes curved from

a straight into a horse shoe form, and shortly di-
vides into 3 cavities (fig 86.) Of these three
cavities which are developed in all Vertebrata
the most posterior is the simple auricle; the
middle one the simple ventricle; and the most an-
terior the bulbus arteriosus. These 3 parts of the
heart contract in succession. The auricle and
the bulbus arteriosus at this period lie at the
extremities of the horse shoe. The bulging out
of the middle portion inferiorly gives the first
indication of the future form of the ventricle. (fig 86.)

The septum dividing the ventricle commences at the
apex and extends upwards. (fig 87.)

When it is complete, a septum is developed in
the bulbus aortae separating the roots of the
proper aorta and the pulmonary artery. The sep-
tum of the auricles is developed from a semilu-
nar fold, which extends from above downwards.
In man the septum between the ventricles, accor-
ding to Meckel, begins to be formed about the 4th
week and at the end of 8 weeks is complete.

The Omphalo-mesenteric vein which veines the
blood from the veins of the mesentery, is common
to all vertebrate animals. When the liver is
formed, this vein gives branches to it, and re-
ceives from it others, the venae hepaticae. Be-
tween the 2 sets of hepatic veins, the trunk of
the omphalo mesenteric vein becomes obliterated,
and then the vena portae is formed as an inde-
pendent

vessel conveying blood to the liver, while the same blood is carried out of the organ by the distinct venae hepaticae.

Circulation in the foetus, refer to particularly if the limits of the lecture will permit.

Development of the Alimentary Canal.

The alimentary canal, which as already described, is a kind of diverticulum from the umbilical vesicle, is at first an uniform straight tube, which gradually becomes divided into its special parts, stomach, small intestine, and large intestine (fig 91). The stomach originally has the same direction as the rest of the canal; its cardiac extremity being superior, its pylorus inferior. The first changes which of position the alimentary canal undergoes consist in the stomach assuming an oblique direction, and in the small intestine taking a new course from the stomach towards the navel, and, after making an abrupt bend there, returning towards the middle of the body in order to make its final course & reach the anus. The limit between the small and the large intestine lies in the part returning from the umbilicus, the ductus omphalo-mesentericus being connected with the lower part of the small intestine. (see plate 14 fig 4 of Kölliker). The part of the small intestine near the umbilicus gradually becomes

elongated and convoluted (plate 3 same work), and at the same time the large intestine rises so as to form its great arch round the greater part of the small intestine.

The principal glands in connection with the intestinal canal are the salivary, pancreas and the liver. In Mammalia each salivary gland first appears as a simple canal with bud-like processes (fig 92), lying in a gelatinous nidus or blastema, and communicating with the cavity of the mouth. As the development of the gland advances, the canal becomes more and more ramified, increasing at the expense of the blastema in which it is still enclosed. The branches or salivary ducts constitute an independent system of closed tubes (fig 93 Kölles). The pancreas is developed exactly as the salivary glands.

The liver in the embryo of the bird is developed by the protrusion as it were, of a part of the walls of the intestinal canal, in the form of 2 conical hollow branches which embrace the common vitelline stem (fig 94). The cones increase in length pushing before the ramifications of blood vessels, while their base becomes gradually narrowed, and assumes the form of a cylindrical duct. At the same time internal ramifications are developed in the cavities of the cones, and these become united at their base, in consequence of more and more of the surrounding part of the intestinal

parietes being taken up to form them, till at last the part that separated them is removed to a distance from the intestine; and the cavities originally double, open by one mouth into the intestinal. The gall-bladder is developed as a diverticulum from the hepatic duct.

Development of the Respiratory Apparatus.

The lungs, at their first development, appear as small tubercles or diverticula from the abdominal surface of the oesophagus. They are united at the anterior part of their circumference and here a pedicle is formed which becomes elongated into the trachea (see fig 95. A, B.)
Soon afterwards, the lung is seen to consist of a mass of caecal tubes issuing from the branches of the trachea. (fig 95. C). The diaphragm is early developed.

The Wolffian Bodies, & Urinary Apparatus.

The Wolffian bodies have been already several times mentioned. They are organs peculiar to the embryonic state, and may be regarded as temporary, though not rudimental kidneys; for they seem to discharge the functions of those latter organs, though they are not developed into them. They probably bear the same relation to the persistant kidneys, as the branchiae of Amphibia do to the lungs which succeed them.
In Mammalia the Wolffian bodies are

bean shaped, and are composed of transverse caecal canals, united by an excretory duct which leads from the lower extremity of the organ to the sinus urogenitalis or cloaca of the foetus (Rubig 96. 4). The Kidneys (2) and suprarenal capsules (1) are developed behind them. Their size is at first so great, that they entirely conceal the kidneys; but in proportion as the latter bodies increase in size, they grow relatively smaller, and come to be placed more inferiorly. Along the outer border of the gland runs the efferent part of the generative apparatus (5) viz the Fallopian tube or vas deferens, which at first have the same conformation, and terminate by a free extremity; whilst the testicle or ovary (2) is formed independently at the internal excavated border of the organ.

46

Touch.

Geo. D. Gibb M.D.

17th February 1852

To illustrate

Plate 63 of Hassall
Capillary net work, lips. Carpenters manual p 545
Nerves of thumb ——— do do ——— 546
Nerves of lip ——— do do ——— 222
drawing 82 Todd. Vessels of papillae of heel
do C fig 101 do Nerves of papillae of tongue
Whiskers of seal and other animals.

Intentionally shall, to fill up accidents.

Touch. This is the simplest and most rudimentary of all the special senses, and may be considered as an exalted form of common sensation, from which it rises, by imperceptible gradations to its highest state of development in some particular parts. It has its seat in the whole of the skin and in certain mucous membranes, as that of the mouth, and is therefore the sense most generally diffused over the body. It is extremely delicate in particular parts of the skin, as in the fingers, the tongue and the lips, which are provided with abundant papillae. It is also that sense which exists most extensively in the animal Kingdom. In many of the mammalia it appears to reside in the tip of the tongue and in the lips. In many of the higher animals again, the hairs are most delicate instruments of touch; for although themselves insensible, their bulbs are seated upon cutaneous papillae, copiously provided with nerves and blood vessels, in such a manner that any motion or vibration communicated to the hair must produce an impression upon the papilla at its base. Such an organization is found in those long stiff hairs which are known as the vibrissae or whiskers of the feline tribe, and which are particularly large in the Seal. These sensitive hairs are also highly developed in many of the Rodentia, such as the Rat & Rabbit, and it has been proved by experiment, that, if they be cut off, the animal loses in great degree its power of guiding its movements in the dark.

For further observations on Touch in animals
see Todd & Bowmans Physiology page 428
of volume 1 —

It is probable that the sense of touch is never absent in any species of the Animal Kingdom.

It is the earliest sense called into operation and the least complicated in its impressions and mechanism.

The Nerves of Touch are the same, or at least are derived from the same part part of the cerebro spinal centre as those of common sensation. They are the posterior roots of the spinal nerves, and some fibres of the 8th and 5th cerebral nerves. The peripheral organ of touch to which they are distributed is a tissue everywhere diffused over the sentient surface, but which in most situations is elevated into papillae more or less distinct from one another, and closely set according to the tactile power. The nerves of touch are remarkable for the ganglia which are formed upon them on their emergence from the vertebral canal, and for the subsequent admixture with most of them of nerves of motion. In these respects they differ from those of the other special senses except taste, which ranks next to touch in the ascending scale.

The structure of the Tongue and of its papillae has been already considered in my lecture on Taste. A general account has also been given of the structure of the Skin and of its functions as an organ of perspiration and absorption, when lecturing upon it. Its peculiarities as a sensitive integument, and especially as an organ of touch, have now to be considered.

By means of its toughness, flexibility, and elasticity the Skin is eminently qualified to serve as the general integument of the body, for defending the internal parts from external violence, and readily yielding and adapting itself to their various movements and changes of position. But from the abundant supply of sensitive. But from the abundant supply of sensitive nerve fibres which it receives, it is enabled to fulfil a not less important purpose in serving as the principal organ of the sense of touch. The entire surface of the skin is extremely sensitive, but its tactile properties are due, chiefly to the abundant papillae with which it is studded.

shown all plates on Plate 63 of Hassall.

These papillae have already been described as conical elevations of the chorion, more prominent and more densely set at some parts than others. The parts on which they are ~~xxx~~ most abundant and most prominent are the palmar surface of the hands and fingers, and the soles of the feet — parts, therefore, in which the sense of touch is most acute. Over other parts of the skin they are more or less thinly scattered, and are scarcely elevated above the surface. Their average length is about $\frac{1}{100}$th of an inch, and at their base they measure about $\frac{1}{250}$th of an inch in diameter. Each papilla is abundantly supplied with blood, receiving from the vascular plexus in the cutis one or more minute arterial twigs, which divide into capillary

loops into its substance, and then reunite into a minute vein, which passes out at its base.

The abundant supply of blood which the papillae thus receives explains the turgescence or kind of erection which they undergo when the circulation through the skin is active. Each papilla contains also a terminal nerve-fibre, on which its exquisite sensibility depends. The mode in which this fibre terminates, whether by a loop or by a free extremity, or after uniting with its external white substance, by being lost in the tissue of the papillae, has still to be ascertained.

I will show you plates of the tactile nerves at the extremity of the human thumb; tactile nerves at the surface of the lip; and nerves of a compound papillae near the point of the tongue.

Carpenters Manual pages 222 & 546. Todd page 440, fig 101. C

The bloodvessels and terminal nerve fibres of the skin are distributed, in a kind of fibrous structure, which gives to the papillae its form and a certain degree of firmness.

Although destined especially for the sense of touch, the papillae are not so placed as to come into direct contact with external objects, but, like the rest of the surface of the skin, are covered by one or more layers of epithelium, forming the cuticle or epidermis. The papillae adhere very intimately to the cuticle, which is thickest in the spaces between them, but tolerably level on its outer surface; hence, when stripped off from the cutis,

as after maceration, its internal surface presents a series of pits and elevations corresponding to the papillae and their interspaces, of which it thus forms a kind of mould. Besides affording by its impermeability a check to undue evaporation from the skin, and providing the sensitive cutis with a protecting investment, the cuticle is of service in relation to the sense of touch. For, by being thickest in the spaces between the papillae, and only thinly spread over the summits of these processes, it may serve to subdivide the percipient surface of the skin into a number of isolated points, each of which is capable of receiving a distinct impression from an external body. By covering the papillae it renders the sensation produced by external bodies more obtuse, and in this manner also is subservient to touch: for unless the very sensitive papillae were thus defended, the contact of substances would give rise to pain, instead of the ordinary impressions of touch. This is shewn in the extreme sensitiveness and loss of tactile power in a part of the skin when deprived of its epidermis. If the cuticle is very thick, however, as on the heel, touch becomes imperfect or is lost, through the inability of the tactile papillae to receive impressions through the dense and horny layer covering them.

The sensations of the common sensitive nerves have as peculiar a character as those of any other organ of sense. The sense of touch

renders us conscious of the presence of a stimulus, from the slightest to the most intense degree of its action, neither by sound, nor by light, nor by colour, but by that indescribable something which we call feeling, or common sensation. The modifications of this sense often depend on the extent of the parts affected. The sensation of pricking, for example informs us that the sensitive particles are intensely affected in a small extent; the sensation of pressure indicates a slighter affection of the parts in a greater extent, and to a greater depth. It is by the depth to which the parts are affected, that the feeling of pressure is distinguished from that of mere contact.

By the sense of touch the mind is made acquainted with the size, form, and other external characters of bodies. And in order that these characters may be easily ascertained the sense of touch is especially developed on those parts which can be readily moved over the surface of bodies. Touch in its more limited sense, or the act of examining a body by the touch, consists merely in a voluntary employment of this sense combined with movement, and stands in the same relation to the sense of touch or common sensibility, generally, as the act of seeking, poloring, or examining odours, does to the sense of smell. Every sensitive part of the body which can, by means of movement, be brought into different relations of contact with external bodies, is an organ of "Touch".

* Bostock mentions a well known case of a female in the country parts of England, entirely without either upper or lower extremities, who has supplied the defect of hands by the tongue and lips, combined with the motions of the muscles of the neck.

p. 728 of his Physiology

Fenwicks Carpenter

* refer to Muller & Carpenter Manual or for these if necessary

to one part, consequently, has exclusively this function. The hand, however is best adapted for it, by reason of its peculiarities of structure, — namely, its capability of pronation and supination, which enables it, by the movement of rotation, to examine the whole circumference of a body; the power of opposing the thumb to the rest of the hand; and the relative mobility of the fingers. *

The perfection of the sense of touch on different parts of the surface is proportioned to the power which such parts possess of distinguishing and isolating the sensations produced by 2 points placed close together. This power depends, at least in part, on the number of primitive nerve-fibres distributed to the part; for the power the primitive fibres which an organ receives, the more likely is it that sensual impressions on different contiguous points will act on only one nervous fibre, and hence be confounded, and perhaps produce but one sensation. Experiments to determine the tactile properties of different parts of the skin, as measured by this power of distinguishing distances were made by E. H. Weber. The experiments consisted in touching the skin, while the eyes were closed, with the points of a pair of compasses sheathed with cork, and in ascertaining how close the points of the compasses might be brought to each other and still be felt as 2 bodies.

He examined in this manner nearly every part of the surface of the body, and has given tables

*

shewing the relative degrees of sensibility of different parts. ~~He examined in this manner~~ Experiments of a similar kind have been performed also by Valentin: and, among the numerous results obtained by both these investigators, it appears that the extremity of the third finger and the point of the tongue, are the parts most sensitive; a distance of as little as half a line being here distinguished.

These facts will not astonish you when you examine the plates of the nerves of these parts some of which I have just shown you — shew nerves again if necessary.

Next in sensitiveness to these is the mucous surface of the lips, which can perceive the 2 points of the compass when separated to the distance of about a line and a half: on the dorsum of the tongue they require to be separated 2 lines.

The parts in which the sense of touch is least acute, are the neck, the middle of the back, the middle of the arm, and the middle of the thigh, on which the points of the compass have to be separated to the distance of 30 lines to be perceived as distinct points (Weber). Other parts of the body possess various degrees of sensibility intermediate between the above extremes.

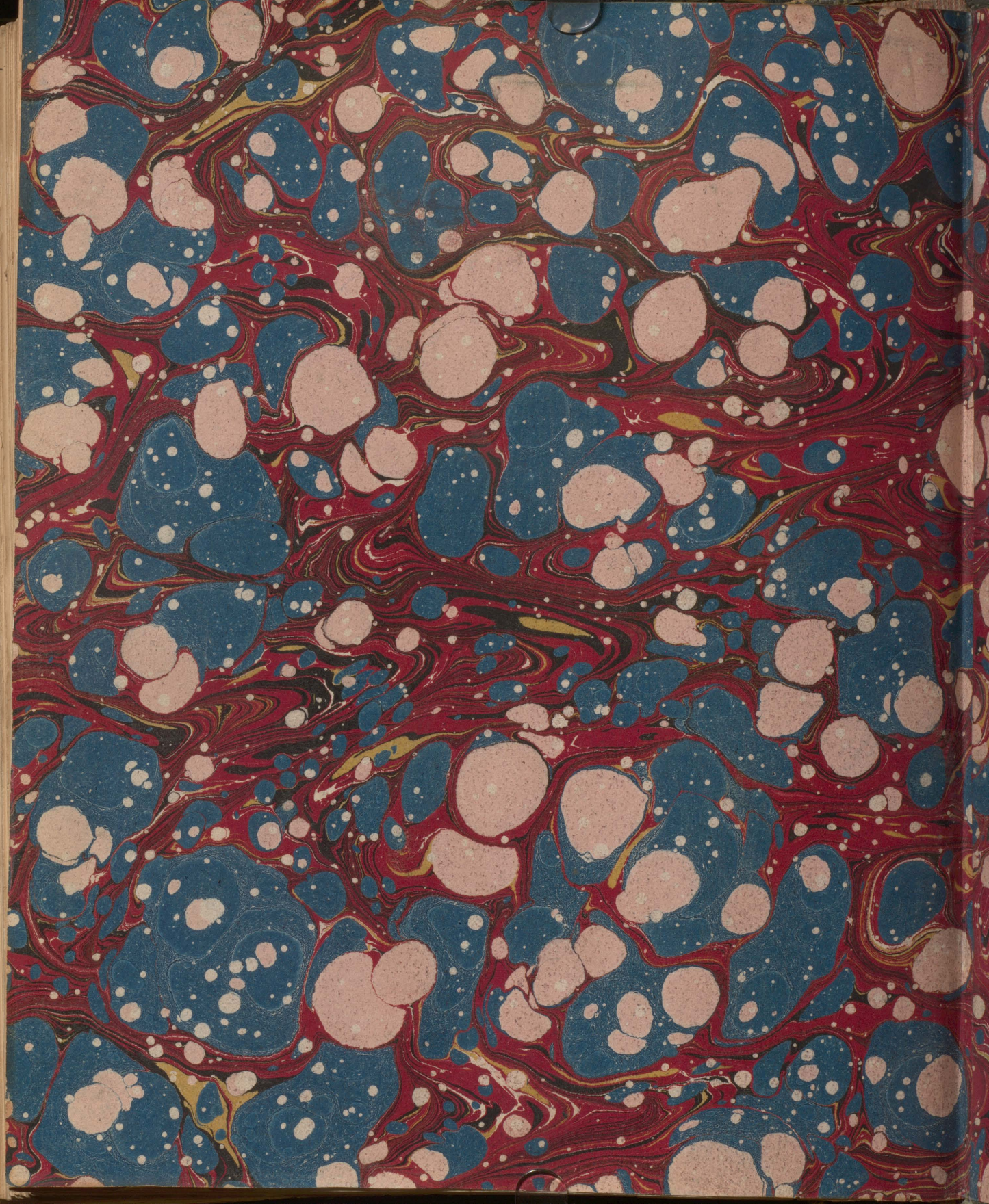
In blind persons the sense of touch supplies many of the impressions which under ordinary circumstances are produced by sight. They are, however,

very materially aided by the sense of hearing, more especially in what regards their communication with their fellow-creatures; this sense, through the intervention of speech, being the one which we employ in the common intercourses of society. But it occasionally happens, that we meet with persons who are deprived of the senses both of sight and hearing, and yet, as far as we can judge, possess the full power of receiving the perceptions of external objects were they provided with the necessary instruments for acquiring the impressions of them.

An extremely interesting case of this description is mentioned by Bostock as occurring in Scotland, where a man was born blind and deaf, yet whose mental powers appear to have been naturally perfect. Through kind and intelligent relatives he enjoyed every advantage of which his bodily situation admitted, for obtaining information by means of the other external senses. His conceptions of external objects, most of what may be termed his general or abstract ideas, were principally derived from the touch, and it is not a little curious to observe, with what perseverance he pursued his investigations of the various objects that were presented to him. He appeared to possess a peculiar delicacy of touch, and still more of smell; and by means of these senses alone he acquired a knowledge of the nature and presence of surrounding bodies, which would previously have been thought impossible.

The case of Sanderson, who although he lost his sight at 2 years old, became Professor of Mathematics at Cambridge, is well known; amongst his most remarkable faculties, was that of distinguishing genuine medals from imitations, which he could do more accurately than many connoisseurs in full possession of their senses. The process of the acquirement of the power of recognising elevated characters by the touch, is a remarkable example of this impressionability. When a blind person first commences learning to read in this manner, it is necessary to use a large type; and every individual letter must be felt for some time, before a distinct idea of its form is acquired. After a short period of diligent application, the individual becomes able to recognise the combinations of letters in words, without forming a separate idea of each letter; and can read line after line, by passing the finger over each, with considerable rapidity. Now when this power is once thoroughly acquired, it is found that the size of the type may be gradually diminished; and this seems to indicate, that the sensations themselves are rendered more acute, by the frequent application of them in this direction. As an instance of the correctness which may be conveyed to the mind, of the forms and surfaces of a great variety of objects, and of the sufficiency of these notions for accurate comparison, Dr Carpenter mentions the case of a blind friend of his own, who has acquired a very complete knowledge of Conchology, both

recent and fossil; and who is not only able to recognise every one of the numerous specimens in his own Cabinet, but to mention the nearest alliances of a shell previously unknown to him, when he has thoroughly examined it by his touch.

Many instances are on record, of the acquirement by the blind, of the power of distinguishing the Colours of surfaces, which were similar in other respects; and however wonderful this may seem, it is by no means ~~improbable~~ incredible. For it is to be remembered that the difference of colour depends upon the position and arrangement of the particles composing the surface, which under it capable of Reflecting one Ray, whilst it absorbs all the rest; and it is quite consistent with what we know from other sources, to believe that the Sense of touch may become so refined, as to communicate a perception of such differences.

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